1986 Water Resources Development Act Section 903(a), Specific Project Report and Environmental Assessment

Connecticut River Basin Fish Passage Facilities for Townshend and Ball Mountain Lakes West River, Vermont

February 1992

US Army Corps of Engineers
New England Division

REPORT DOCUMENTATION PAGE

Form Approved.
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
February 1992

3. REPORT TYPE AND DATES COVERED
Environmental Assessment

4. TITLE AND SUBTITLE
Connecticut River Basin Fish Passage Facilities for Townshend and Ball Mountain Lakes, West River, Vermont.

5. FUNDING NUMBERS

6. AUTHOR(S)
U.S. Army Corps of Engineers, New England Division

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers, New England Division
424 Trapelo Road
Waltham, MA 02254-9149

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers, New England Division
424 Trapelo Road
Waltham, MA 02254-9149

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
The study was authorized by Water Resources Development Act, 1986, Sect. 903(a) & Sect. 872, (PL 99-662). Funded by Energy and Water Development Acts 1990 & 1991.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release
Distribution is unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words) This study evaluated alternative measures to allow Atlantic salmon to bypass Townshend and Ball Mountain Lakes, developed a plan to provide the required passage and prepared a report outlining the scope, cost, and impacts of such a plan. Possible alternatives were formulated and evaluated at study team meetings, from which a recommended plan was developed to provide the following: (1) construction of a fish barrier and instream trap downstream of Townshend Lake, (2) modifying the current operation of flow releases at Ball Mountain Lake to provide a 25 foot pool from the end of the last weekend in April to June 1, (3) automating one of the gates to facilitate the maintenance of a 25 foot pool at Ball Mountain Lake, and (4) modifying the outlet structure at Townshend Lake by notching the weir and providing a splash pool at the foot of the outlet weir to allow for downstream passage of smolts. The total project cost is estimated at $1,285,000. This study recommends that the fish passage facilities presented in this report be approved.

14. SUBJECT TERMS
Atlantic salmon; Townshend Lake; smolt; weirs; Ball Mountain Lake; fish passages; West River, VT; fishes; fish barriers

15. NUMBER OF PAGES
256

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

CONNECTICUT RIVER BASIN

FISH PASSAGE FACILITIES

FOR

TOWNSHEND AND BALL MOUNTAIN LAKES

WEST RIVER, VERMONT

1986 WATER RESOURCES DEVELOPMENT ACT

SECTION 903(a), SPECIFIC PROJECT REPORT

AND

ENVIRONMENTAL ASSESSMENT

FEBRUARY 1992

Department of the Army
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254-9149

EXECUTIVE SUMMARY

The Water Resources Development Act of 1986 (PL 99-662) authorized the Corps of Engineers to design, construct, operate and maintain facilities to allow passage of Atlantic salmon at the Corps' Townshend and Ball Mountain Lake projects in Vermont. This report documents investigations accomplished to determine the best plan for accomplishing this task.

As authorized, these facilities must provide for upstream passage of migrant adult salmon, and downstream passage of juvenile salmon (smolt) at both projects. To address this requirement, experts of varied disciplines, including the area of salmon restoration, were assembled to develop a plan that optimized fish passage, economic efficiency and environmental protection. Possible alternatives were formulated and evaluated and discussed at study team meetings, from which a recommended plan was developed to provide the following:

- o construction of a fish barrier and instream trap downstream of Townshend Lake; salmon caught at this location would be transported to locations upstream of the dams at Townshend and Ball Mountain Lakes.
- o modifying the current operation of flow releases at Ball Mountain Lake to provide a 25-foot pool from the end of the last weekend in April to June 1;
- o automating one of the gates to facilitate the maintainance of a 25-foot pool at Ball Mountain Lake; and
- o modifying the outlet structure at Townshend Lake by notching the weir and providing a splash pool at the foot of the outlet weir to allow for downstream passage of smolts.

The total project cost is estimated at $1,285,000. This includes planning, engineering and design, and construction.

This study recommends that the fish passage facilities presented in this report be approved.

SECTION 903(a), SPECIFIC PROJECT REPORT
CONNECTICUT RIVER BASIN
FISH PASSAGE FACILITIES FOR
TOWNSHEND AND BALL MOUNTAIN LAKES
WEST RIVER, VERMONT

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SECTION I

INTRODUCTION

The inability of Atlantic salmon to bypass the Corps of Engineers dams at Townshend and Ball Mountain Lakes on the West River in Vermont has resulted in efforts by Federal and State officials to seek methods of allowing such passage at these multi-purpose flood control facilities. Fish passage facilities at these projects were authorized by the Water Resources Development Act of 1986. Funds to prepare this study were provided by the Energy and Water Development Acts for 1990 and 1991.

STUDY AUTHORITY

This study was authorized by Section 872 of the Water Resources Development Act of 1986 (Public Law 99-662-November 17, 1986), which states:

"SECTION 872. CONNECTICUT RIVER BASIN.

(a) Subject to section 903(a) of this Act, the comprehensive plan for the control of floodwaters in the Connecticut River Basin, Vermont, New Hampshire, Massachusetts, and Connecticut, authorized by section 5 of the Act of June 22, 1936 (49 Stat. 1572), is modified to authorize and direct the Secretary to design, construct, operate, and maintain facilities at Townshend Dam, West River, Vermont, to enable upstream migrant adult Atlantic salmon to bypass that dam and Ball Mountain Dam, Vermont, and to provide at both Townshend and Ball Mountain Dam facilities as necessary for the downstream passage of juvenile Atlantic salmon, at a total cost of $1,000,000, with a first Federal cost of $1,000,000.

(b) Prior to construction of the work authorized by this section, non-Federal interests shall agree to hold and save the United States harmless for any damages incurred in the construction and operation of such fish-passage facilities, and provide all lands, easements, rights-of-way, and relocations as may be reasonably necessary for the construction and operation of the fish-passage facilities."

STUDY OBJECTIVE

The purpose of this study was to evaluate alternative measures to allow Atlantic salmon to bypass Townshend and Ball Mountain Lakes, develop a plan to provide the required passage and prepare a report outlining the scope, cost, and impacts of such a plan.

STUDY PARTICIPANTS AND COORDINATION

This study was conducted by the New England Division, Corps of Engineers. To insure effective coordination with interested agencies, a technical working group, consisting of Federal, State and other officials and individuals, was formed early in the study. Representatives of the U. S. Fish and Wildlife Service, the Vermont Department of Fish and Wildlife, the U. S. Forest Service and other interests such as white water canoeing (Appalachian Mountain Club), participated in several meetings held in the study area or at the offices of group members.

These meetings provided a forum for exchange of information and participation in the plan formulation process. The U. S. Fish and Wildlife Service, Sunderland, Massachusetts office, under contract to the Corps of Engineers, also conducted two studies concerning the downstream migration of Atlantic salmon smolts.

OTHER STUDIES

After several years of study and coordination, the Federal Energy Regulatory Commission, on February 1988, issued a license to the communities of Londonderry, Windham, Wardsboro, Dummerston and Newfane, Vermont to construct, operate and maintain a hydroelectric project at Ball Mountain Lake (FERC Project No. 8433-003). However, a 1990 decision of the Vermont Supreme Court effectively denied this application by ruling that the Towns did not have the authority to sell power to Vermont public utilities on a wholesale basis. Hydroelectric Development Inc., of Colorado, the developer of the project, is presently evaluating options concerning this matter. These include requesting an extension or a transfer of the license.

The New England Division, U.S. Army Corps of Engineers completed Reconnaissance Reports concerning hydropower development at Ball Mountain and Townshend Lakes in December 1982 and January 1983, respectively. Both reports recommended that studies proceed to the feasibility stage, but due to a change in National priorities, no further studies were conducted.

The New England Division, U.S. Army Corps of Engineers completed the Townshend Lake Water Quality Evaluation in 1983 and the Ball Mountain Water Quality Evaluation in 1987. These reports evaluate the results of water quality sampling conducted at these projects.

In April 1980, the U.S. Fish and Wildlife Service completed a report entitled "A Strategic Plan for the Restoration of Atlantic Salmon to the Connecticut River Basin". This report was subsequently updated and a revised document was issued in September, 1982.

SECTION II

PROBLEM IDENTIFICATION

The Townshend and Ball Mountain Lake projects are two elements of a comprehensive plan for flood protection in the Connecticut River Basin that includes a system of 16 dams and reservoirs and a series of local protection projects at heavily urbanized damage centers. Both projects are situated in the West River Watershed in southern Vermont.

Operation of these projects provides flood protection to communities immediately downstream on the West River and to communities further downstream on the Connecticut River in Vermont, New Hampshire, Massachusetts and Connecticut.

WEST RIVER WATERSHED

The West River Watershed, shown on Plate 1, is located in southern Vermont. It has a drainage area of 423 square miles of which 278 and 172 square miles lie upstream from Townshend and Ball Mountain Lakes, respectively. The watershed is generally elongated in shape, with a length of approximately 38 miles and a maximum width of 18 miles. Elevations vary from 220 feet NGVD at the mouth of the river to 3,500 feet NGVD at several points on the watershed divide.

The West River rises in the southeastern part of Mount Holly, Vermont. From its source to Ball Mountain Lake, the river flows in a southeasterly direction for about 23 miles and drops about 1,200 feet. It then flows in a general southeasterly direction for about 9.5 miles to Townshend Lake with a drop of about 340 feet. From there the river continues in a southeasterly direction about 19.5 miles and drops about 240 feet to its confluence with the Connecticut River at Brattleboro, Vermont.

The watershed is primarily forested and underdeveloped. About 11 percent of the basin is situated in the Green Mountain National Forest and development is largely limited to scattered towns. The 1980 population of the watershed was 8,290 or 20 persons per square mile. The principal towns include Londonderry, Jamaica, West Townshend, Townshend, and Newfane. Agricultural land is scarce, and largely confined to relatively flat areas along the West River and its tributaries.

The principal tributaries of the West River are Winhall River, Ball Mountain Brook, Wardsboro Brook and the Rock River with respective drainage areas of about 60, 35, 36 and 59 square miles.

TOWNSHEND LAKE

Townshend Lake is located on the West River about 19.5 miles above its confluence with the Connecticut River. The project consists of a 1700 foot long earth and rockfill dam with a maximum height of 133 feet, outlet works, a side channel spillway, recreation facilities, and storage for

both flood control and recreation. The project location and site plan are shown on Plate 2. A permanent pool is maintained for recreational purposes during the summer and to facilitate gate operations during the winter. The pool has a depth of 21 feet, a surface area of 95 acres and utilizes a net storage of 800 acre-feet. This pool is controlled by a 21 foot high weir. The total flood control storage of the reservoir is 32,900 acre-feet which is equivalent to 5.81 inches of runoff from the 106 square mile drainage area below Ball Mountain Lake. When filled to spillway crest (elevation 553 feet NGVD), the reservoir has a surface area of 735 acres and a length of 4.5 miles. Additional pertinent data on the project and its operation are included in Appendix F.

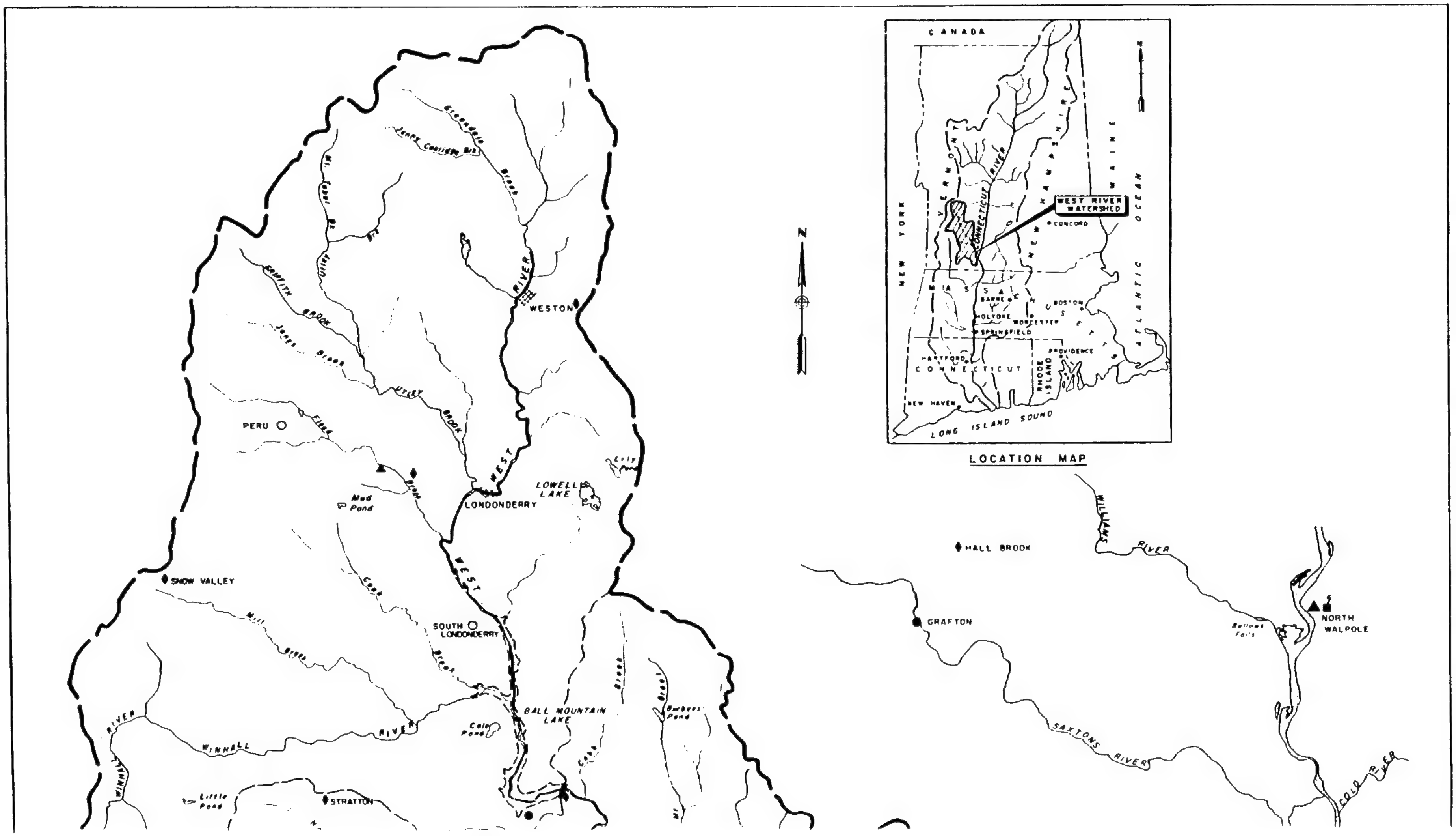
BALL MOUNTAIN LAKE

Ball Mountain Lake is situated on the West River approximately 9.5 miles upstream of Townshend Lake and 29 miles upstream of the Connecticut River. Ball Mountain dam consists of an earth and rockfill dam 915 feet long, with a maximum height of 265 feet. Plate 3 shows the project location and a plan of the dam. Other important project features include a chute spillway, outlet works and control tower, recreational facilities, and storage for both flood control and recreation. A small permanent pool is maintained to facilitate gate operations during the winter months. This 20-acre pool has a water depth of 25 feet. During the summer, a conservation pool with a depth of 65 feet and surface area of 75 acres is maintained. During the late fall, winter and spring, there is a net storage capacity of 54,450 acre-feet set aside for flood control purposes. This is equivalent to 5.90 inches of runoff from the 172 square mile drainage area. During the recreational season, the 65 foot pool reduces this net storage to 52,450 acre-feet or 5.70 inches of runoff. Appendix F contains additional data on the project and its operation.

CLIMATOLOGY

The West River watershed has a variable climate characterized by frequent but short periods of heavy precipitation. It lies in the path of "prevailing westerlies", cyclonic disturbances which cross the country from the west or southwest. The climate is also affected by occasional coastal storms, some of tropical origin, which travel up the Atlantic seaboard.

The basin experiences long cold winters and relatively mild summers. Average annual temperatures vary from 40 degrees Fahrenheit in the hills to 45 degrees Fahrenheit in the valleys. Distribution of precipitation is rather uniform through the year, averaging about 48 inches per year. During the winter months, the precipitation is practically all in the form of snow. Annual snowfall varies from an average of less than 40 inches in the lower elevations to over 100 inches in the higher elevations in the Green Mountains. Snow cover usually persists throughout the winter, especially in the higher elevations.



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NEW HAMPSHIRE
MAINE
ATLANTIC OCEAN
CONNECTICUT RIVER
WEST RIVER WATERSHED
CONCORD
MASSACHUSETTS
BARRE
BOSTON
HOLYOKE
WORCESTER
SPRINGFIELD
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WINHALL RIVER
STRATTON
Little Pond
HALL BROOK
GRAFTON
WILLIAMS RIVER
SAXTONS RIVER
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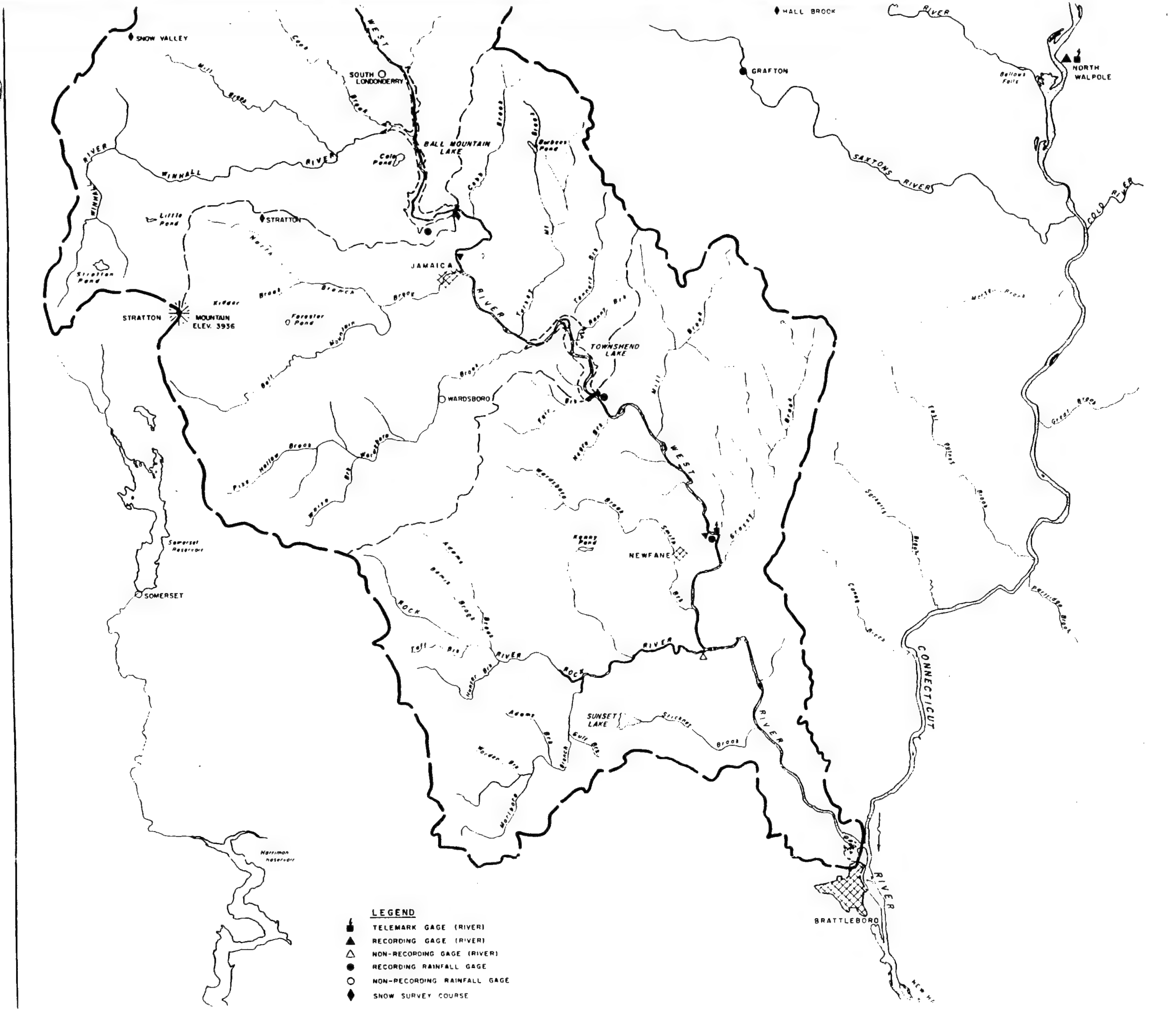
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Forester Pond
WEST RIVER
TOWNSHEND LAKE
WARDSBORO
Wardsboro Brook
NEWFANE
Kenny Pond
Somerset Reservoir
SOMERSET
ROCK RIVER
SUNSET LAKE
Harriman Reservoir
CONNECTICUT RIVER
BRATTLEBORO
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TELEMARK GAGE (RIVER)
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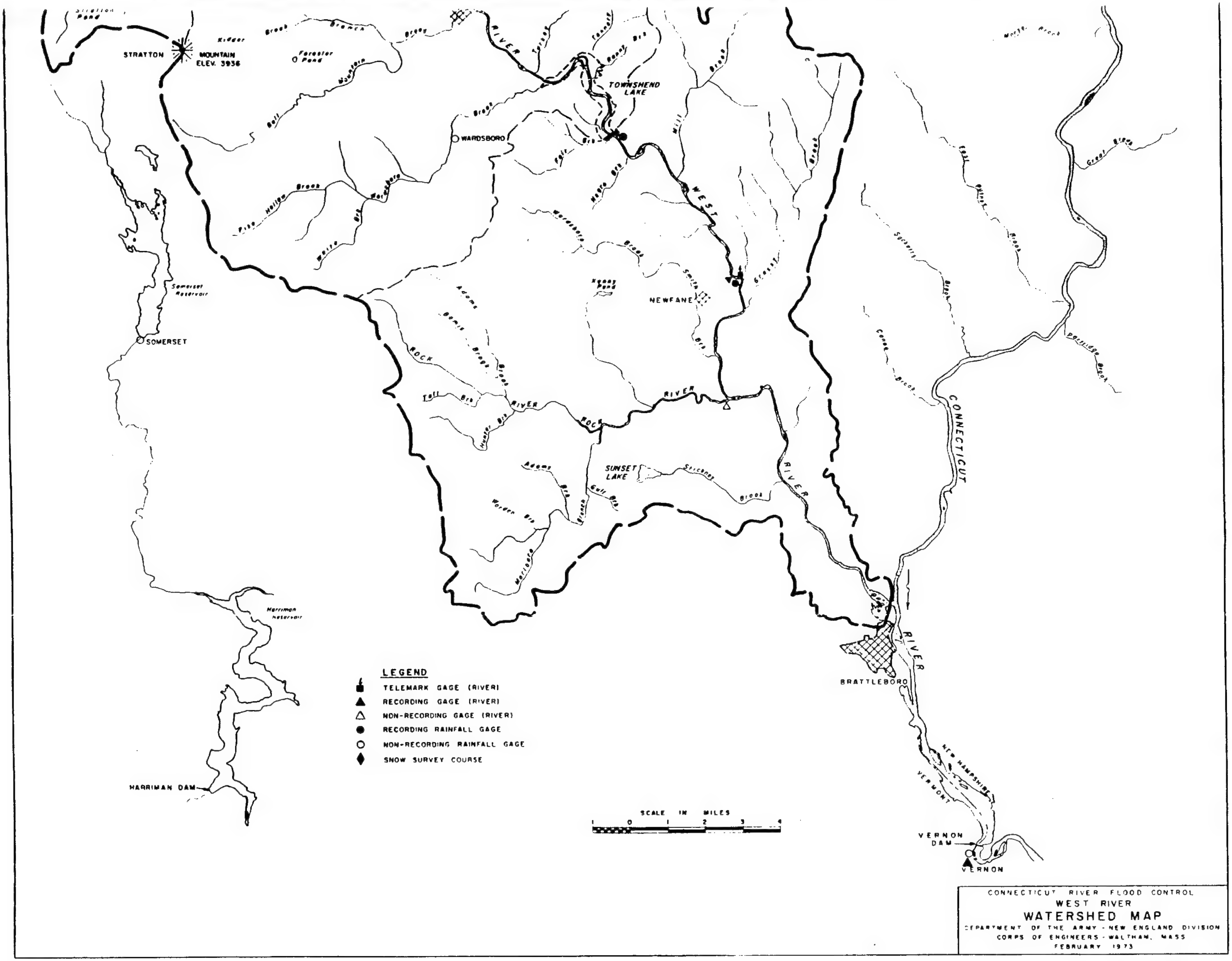
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SUNSET LAKE
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SOMERSET
HARRIMAN DAM
BRATTLEBORO
CONNECTICUT
NEW HAMPSHIRE
VERMONT
VERNON DAM
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LEGEND
TELEMARK GAGE (RIVER)
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SNOW SURVEY COURSE
SCALE IN MILES
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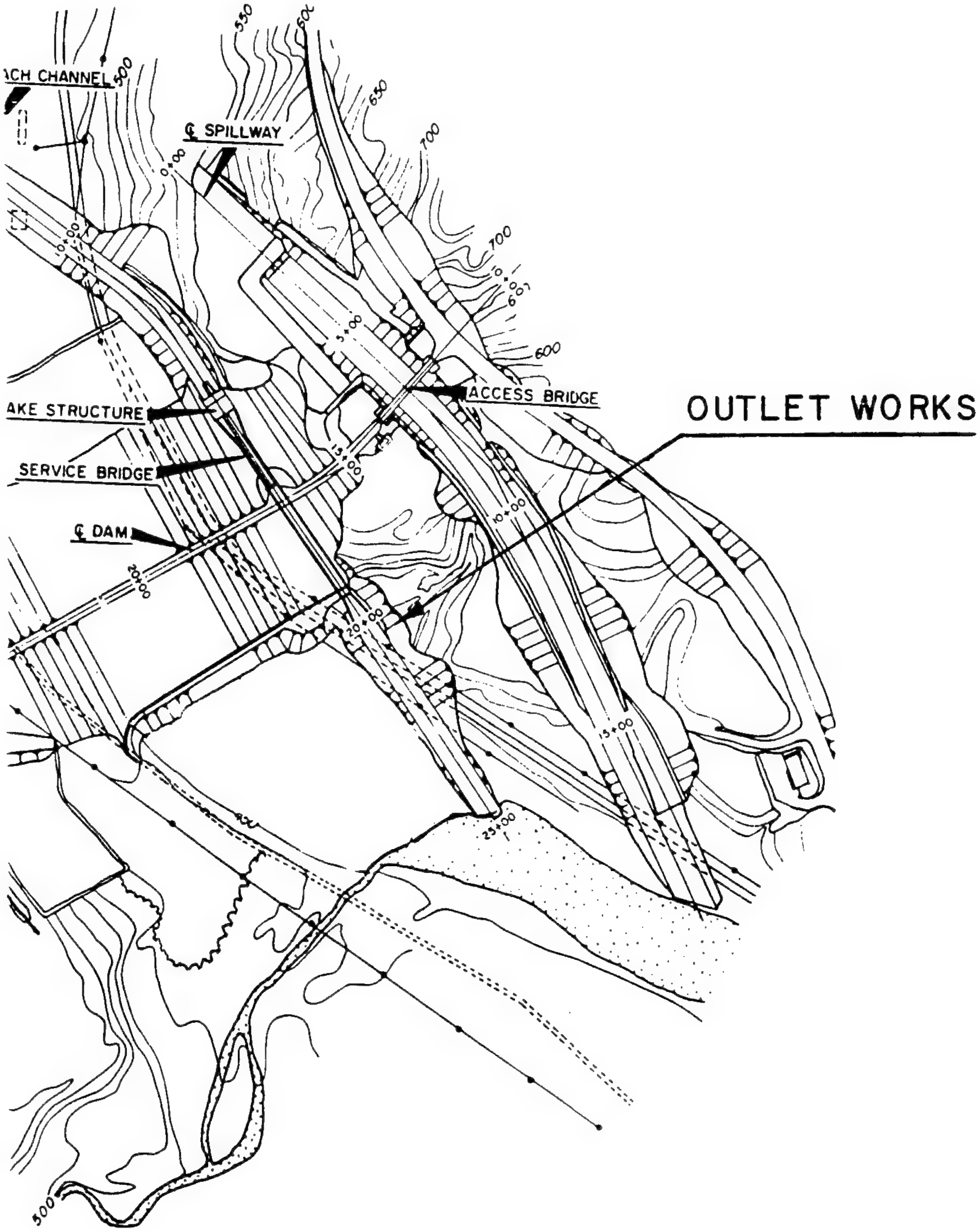
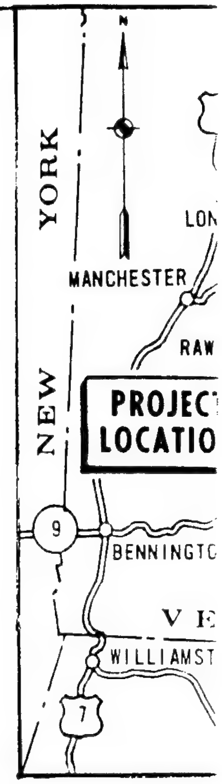
CONNECTICUT RIVER FLOOD CONTROL
WEST RIVER
WATERSHED MAP
DEPARTMENT OF THE ARMY - NEW ENGLAND DIVISION
CORPS OF ENGINEERS - WALTHAM, MASS
FEBRUARY 1973

PLATE 1

3

SITE - TOWNSHEND DAM





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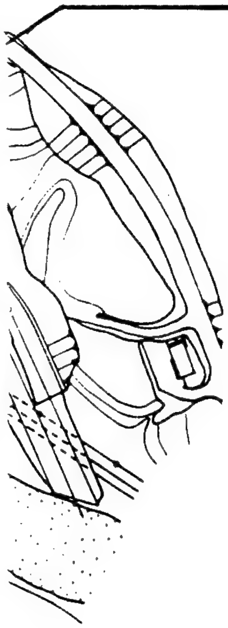
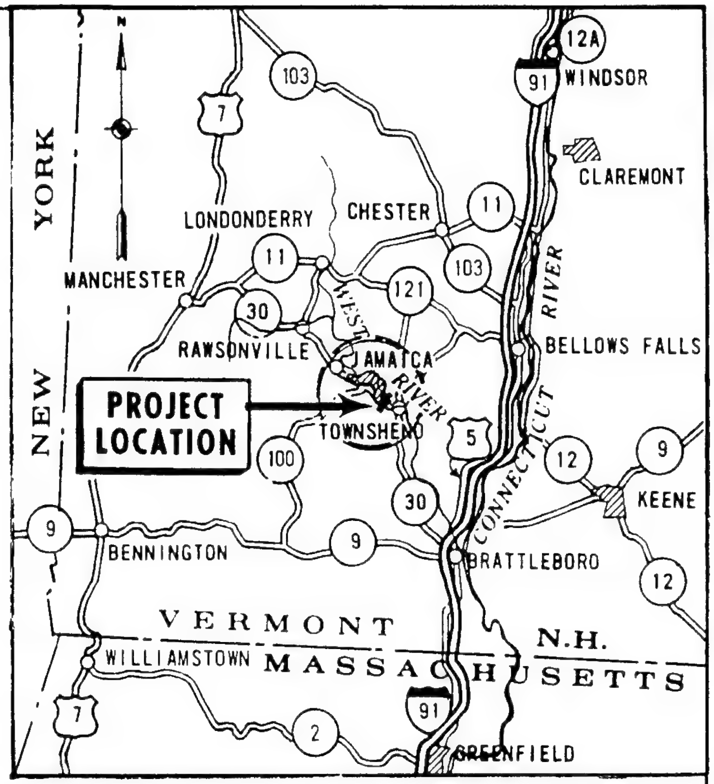




LOCATION MAP

N.T.S.

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS

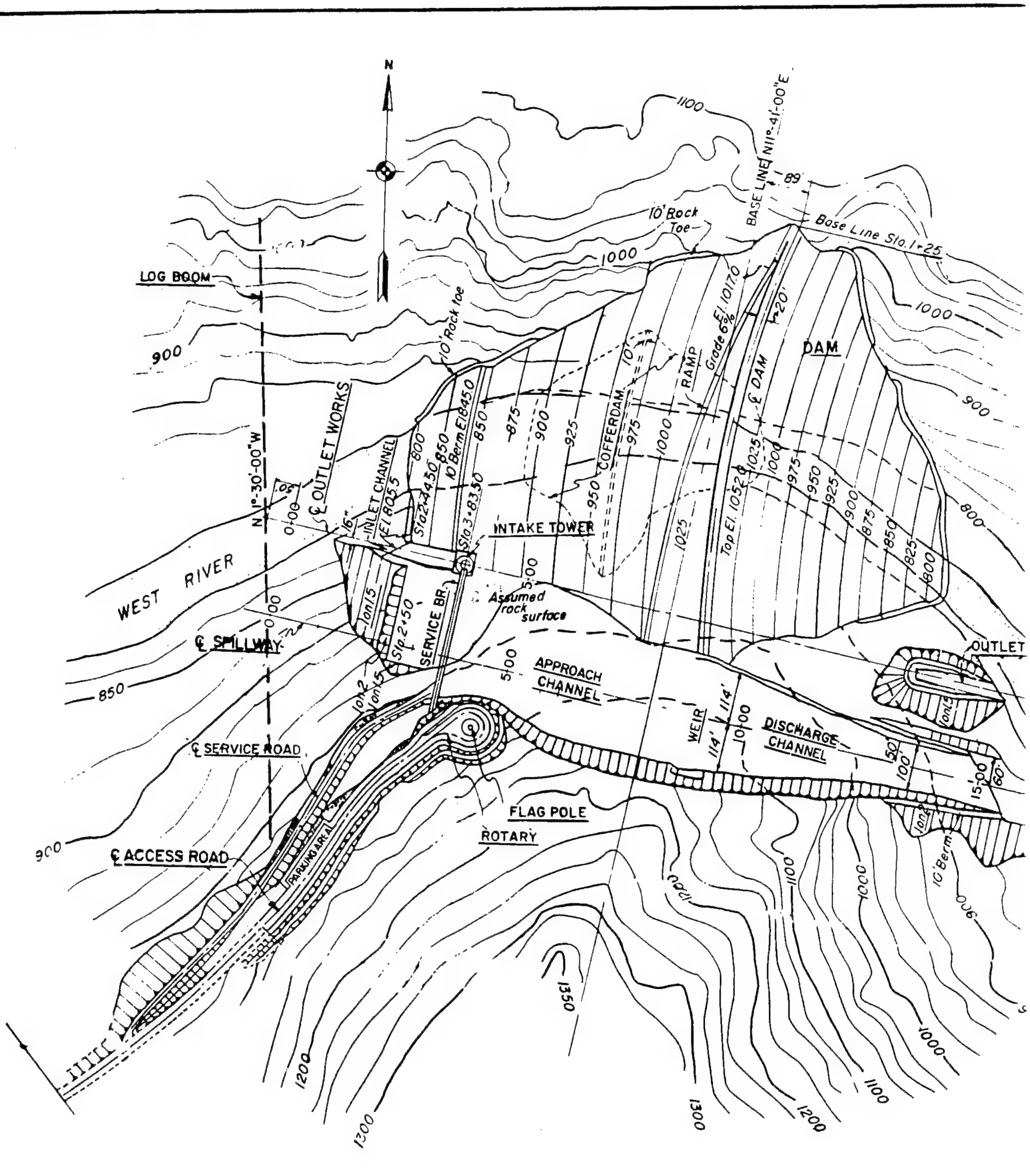
TOWNSHEND LAKE

SALMON RESTORATION PROJECT

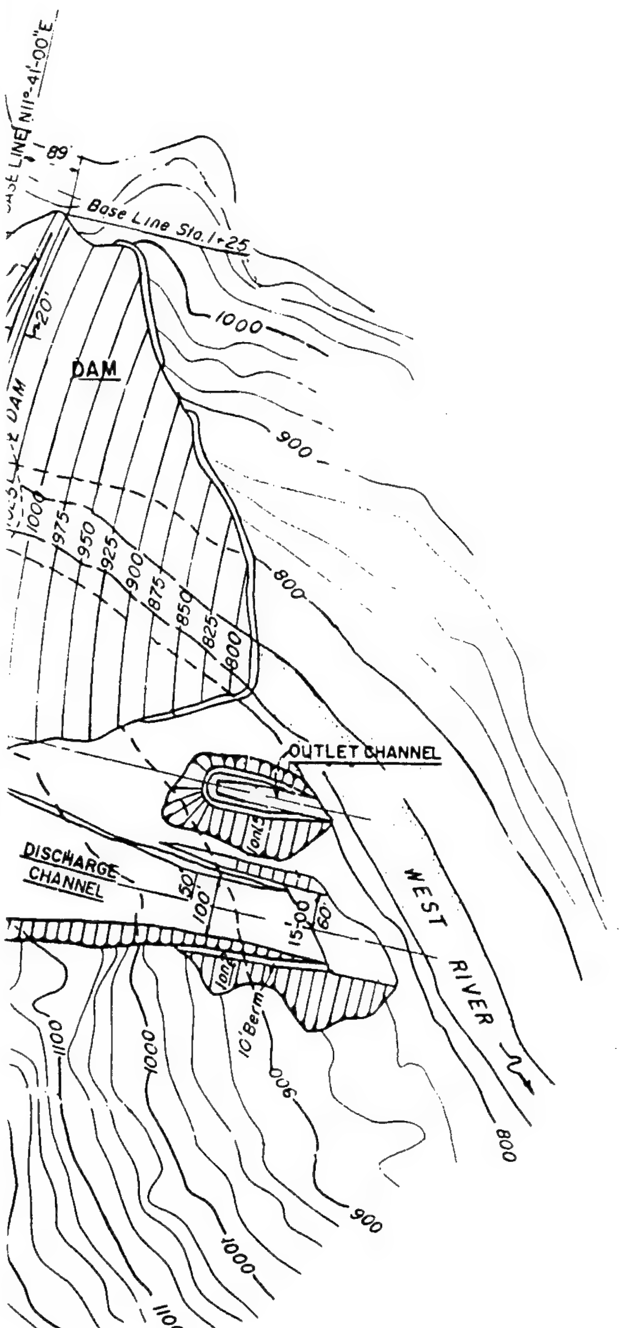
FISH COLLECTION FACILITY

LOCATION AND SITE MAPS

3



SITE - BALL MOUNTAIN DAM



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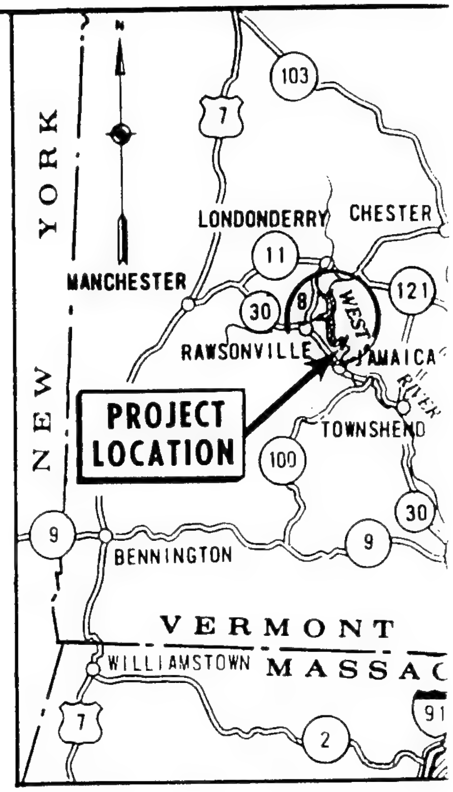

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DEPARTMENT OF THE
NEW ENGLAND DIVISIO
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WALTHAM, MASS

BALL MOUNTAIN

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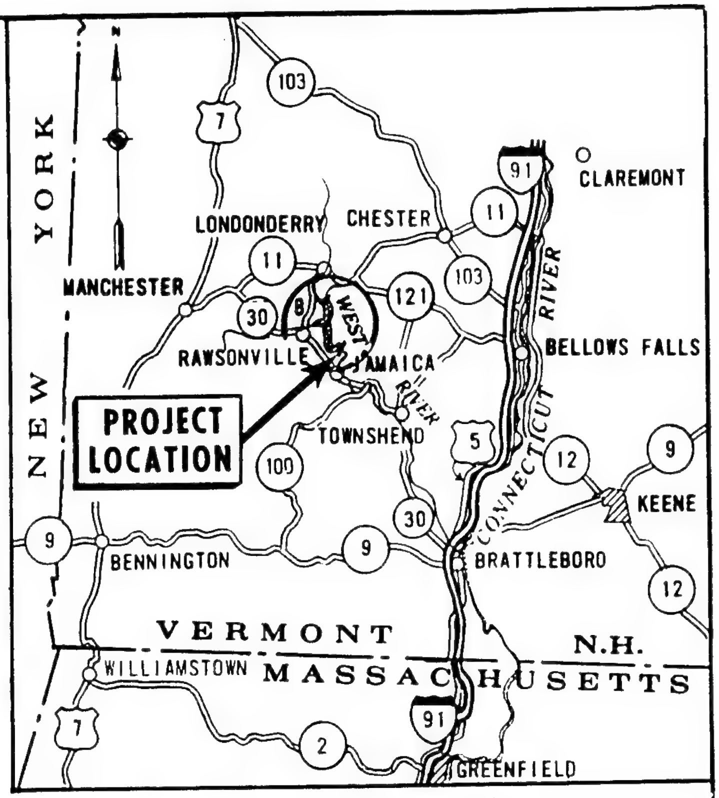


LOCATION MAP

N.T.S.

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

BALL MOUNTAIN LAKE

SALMON RESTORATION PROJECT

FISH COLLECTION FACILITY

LOCATION AND SITE MAPS

PLATE 3

3

TOPOGRAPHY

The general topography of the watershed is hilly with steep wooded slopes from the mouth of the river upstream to Ball Mountain Lake. From this point the watershed becomes comparatively flat with wide valleys, but the rim of the watershed is steep and mountainous. Elevations vary from 220 feet at the mouth of the river, 460 feet at Townshend Dam, 800 feet at Ball Mountain Dam, to over 3,500 feet at several points on the watershed divide. There are few natural or artificial ponds or lakes, and in general, the drainage area is conducive to rapid runoff.

The topography in the vicinity of Townshend Lake is characterized by rugged terrain with rushing streams that flow into the West River Valley. The Green Mountain National Forest extends to the upper limit of the reservoir site and the Townshend State Forest lies south of the site. Above Ball Mountain dam, the river flows through a narrow steep-sided valley, flanked by Ball Mountain to the south and Shatterack Mountain to the north. The greater part of the reservoir is undeveloped and heavily wooded. The Winhall River enters the West River near the center of the reservoir and during flood control operation, creates an arm of the reservoir extending up this stream in a westerly direction.

GEOLOGY

The West River is located within the maturely dissected region of the New England Upland. Thick deposits of glacial till and more pervious outwash sand and gravel make up the valley fill material. Bedrock at Townshend dam is characteristically a quartz-injected schist with gneissic and granitoid phases. Concentrated jointing and fracturing appears to be confined to the upper limits of rock. The spillway and outlet conduit and tower are founded on rock, and relatively few open joints were encountered during construction. Bedrock at Ball Mountain dam is a sericitic schist which is generally exposed or at very shallow depths. The outlet tunnel and spillway cuts were excavated in rock and the intake tower and embankment retaining wall are founded on rock. Post glaciation degradation by the river has removed considerable glacial deposits, but large boulders and rock out crops occupy the river channel below the dam.

WATER QUALITY

Water quality in the West River is rated as Class B by the Vermont Water Resources Board. Class B waters are suitable for bathing, recreation and irrigation, provide good fish and wildlife habitat, and have good aesthetic value. They are also acceptable for public water supply with filtration and disinfection.

The West River watershed consists largely of undeveloped land with no significant point-source discharges. Stream channels tend to be steep causing rapid runoff with turbulent mixing and good aeration. Consequently, water quality would be expected to be good and meet or exceed Vermont Class B criteria. Water quality studies conducted by the Corps of

Engineers in 1983 at Townshend Lake and in 1987 at Ball Mountain Lake determined that the water quality at these projects is good and usually meets or exceeds Class B standards. An additional study by the Corps of Engineers in 1987 entitled: "Atlantic Salmon Suitability at Townshend, Vermont", found that water quality below Townshend Dam was near optimal for salmon survival. This is in agreement with findings by the U.S. Fish and Wildlife Service which concludes that the West River is one of the best rivers in Vermont for salmon habitat and spawning. Additional information concerning water quality parameters is contained in Appendix B and the Environmental Assessment..

FISH AND WILDLIFE

Fish likely to be common downstream of Townshend dam include brown trout, rainbow trout, fallfish, common shiner, blacknose dace, bass, and white sucker. Brown trout are stocked below the Townshend Dam on a put and take basis. Fair Brook, a small tributary which enters the West River about 350 feet downstream from the outlet of Townshend Dam, supports spawning populations of brook trout. Cool waters from Fair Brook also probably provide a refuge for other salmonids during summer months when stream temperatures in the West River are high.

Both Townshend and Ball Mountain Lakes support limited warmwater fisheries. Predominant species present in Townshend Lake include rainbow trout (stocked), yellow perch and rock bass. Smallmouth bass, largemouth bass, bullhead and sunfish are also found in the lake.

Game fish found in Ball Mountain Lake include rainbow trout, brown trout and perch. Trout are stocked by the Vermont Department of Fish and Wildlife on a put and take basis. Brown trout are also stocked in the West River below Ball Mountain Lake.

Mammals observed in areas downstream of Townshend Lake include white tailed deer, fox, fisher, mink, muskrat, and otter. Mink, otter, white tailed deer and racoon commonly occur at Ball Mountain Lake.

Riparian vegetation below Townshend Lake provides good songbird habitat. Mallards, mergansers, cormorants, and other waterfowl occur in the Townshend Lake pool. Osprey have been observed in the vicinity of both Townshend Lake and Ball Mountain Lake.

Uplands adjacent to the Ball Mountain pool provide good habitat for mergansers and mallards. Other waterfowl commonly occurring in the pool include cormorants and canvasback ducks.

VEGETATION

Most of the West River basin is forested. Predominant trees occurring at low elevations include sugar maple, red maple, yellow birch, white birch, red oak, beech, ash, white pine, and hemlock. Red, white, and black spruce and balsam fir are predominant at higher elevations.

Forested areas near Ball Mountain Lake are dominated by white pine, red oak, maples, and white birch. Lands adjacent to the reservoir have been cleared of trees to the 80 foot stage. Vegetation between 65 feet (the normal summer pool elevation) and 80 feet is dominated by grasses, willows and other low shrubs. Due to current management practices, which maintain a 25 foot winter pool and 65 foot summer pool, no aquatic or terrestrial vegetation occurs below the 65 foot stage.

Forested areas near Townshend Lake are also dominated by northern hardwoods, pine, and hemlock. Riparian vegetation in the West River floodplain, downstream of Townshend Lake is dominated by low shrubs; alder, willow, and autumn olive.

THREATENED AND ENDANGERED SPECIES

Several species of rare or threatened freshwater mussels are known to occur in the West River. A field survey conducted in June 1991 found that no mussels occur in areas immediately downstream of Townshend Lake. The substrate at the site is rocky and provides poor mussel habitat. The nearest suitable mussel habitat is situated about 2000 feet downstream of the dam (just downstream of Scott's Covered Bridge). Of the four species of mussels found at this location, the brook floater (Alasmidonta varicosa) is a proposed threatened species in Vermont, and is "candidate species" for inclusion on the Federal list of threatened and endangered species. Brook floaters were most common in a sandy backwater area along the west side of the river, about 100 to 300 feet downstream of the bridge. The other three species are relatively common, and not considered rare, threatened, or endangered by the Federal government or Vermont. A second brook floater population is reportedly present about 4.5 miles downstream of Townshend Lake.

Freshwater mussels are not abundant in the West River between Townshend and Ball Mountain Lakes. The substrate along much of this reach is rocky, and provides poor mussel habitat. The brook floater and eastern pearl mussel (Margariterfera margaritifera), however, are known to occur near the confluence with Wardsboro Brook, about 5 miles downstream of Ball Mountain Lake. The eastern pearl mussel is currently proposed for threatened status in Vermont.

With the exception of transient bald eagles and peregrine falcons, no other Federal or state listed rare, threatened, or endangered species are known to exist in the project area.

HISTORIC AND ARCHAEOLOGICAL RESOURCES

Most of the area immediately downstream of Townshend Lake was extensively disturbed during initial construction of the project. A 1986 Cultural Resource Management Study determined that the area around the dam and outlet structures had no archaeological potential.

A 1982 Cultural Resource Management Study for Ball Mountain Lake identified two areas that could be affected by pool fluctuations. One area was a large terrace, normally submerged by the summer pool and the other area was a small terrace at the northern edge of the summer pool. Further investigations of this small terrace in 1984 determined that the site met the eligibility criteria for nomination to the National Register of Historic Places. An erosion monitoring plan was implemented in this area in 1991. If erosion is significant (greater than 3 meters along the West River embankment within one year), then site stabilization will be accomplished.

SOCIAL AND ECONOMIC RESOURCES

Principal economic activities in the basin include the forest products industry (paper, lumber, and wood products) and tourist industry (skiing, camping, and sight-seeing). Manufacturing is largely limited to light industrial plants located near Brattleboro. Although agricultural land is scarce in the basin, some dairy and sheep farms, and apple orchards are present.

Recreational facilities have been provided at both Ball Mountain and Townshend Lakes. Facilities available at Townshend Lake include a swimming beach, picnic areas, hiking trails, and a boat ramp which provides access to the 95 acre permanent pool. Total visitation at Townshend Lake in 1990 was 428,254 visitor hours. Principal activities were sight-seeing, picnicking, and swimming.

Facilities available at Ball Mountain Lake include hiking trails, a picnic ground near the dam, a boat ramp and a large campground located about 2 miles upstream of the dam. Total visitation at Ball Mountain Lake in 1990 was 395,800 visitor hours. Principal activities were sight-seeing and camping. Swimming, fishing and boating only account for a small percentage of use at Ball Mountain Lake.

Each year the Corps provides controlled releases (about 1500 cfs) from Ball Mountain Lake for whitewater canoeing and kayaking. Prior to 1990, controlled releases were typically made during two weekends in the spring (late April and early May) and during Columbus Day weekend in October. The releases provide outstanding white water conditions between Ball Mountain and Townshend Lakes, and attract hundreds of white water enthusiasts each year. The National White Water Canoeing Championship Races were frequently held in the West River during one of the spring release weekends. Since the fall of 1990, there has been an informal agreement between the Corps, U.S. Fish and Wildlife Service, Vermont Department of Fish and Wildlife, and the Appalachian Mountain Club to have only one spring release, dedicated for recreational purposes. This release would be provided during the last weekend in April if conditions permit. Races were held elsewhere in 1991, and are not currently scheduled to be held at Ball Mountain Lake in future years.

Life Cycle of Atlantic Salmon. Atlantic salmon spawn on gravely substrates in freshwater streams during the fall (mid-October to mid-November). Eggs are deposited in series of depressions (redds), excavated by females, and are covered by a layer of gravel. After spawning, adults (known as kelts) usually return to the ocean or overwinter in freshwater and migrate to the ocean the following spring. Survivorship of kelts is low, and only a small percentage return to freshwater to spawn a second time.

Eggs incubate during the winter and hatch between April and early June. After hatching, larvae remain buried in gravel for about 6 weeks, while slowly absorbing attached yolk sacks. Young salmon (known as fry) emerge from redds in early summer, disperse, and establish territories. Once fry become about 40 mm long they are known as "parr".

In Vermont, most parr remain in freshwater for 2 years before developing into "smolts" and migrating to the ocean. During the smoltification process, parr develop a silvery pigmentation, tolerance to salt water, and schooling behavior. Parr that reach a length of 125-150 mm by spring or early summer of a given year, generally transform into smolts and migrate to the ocean the following spring. The timing of the spring smolt migration is thought to be largely a function of water temperature. Although some outmigration occurs once water temperature reaches $5^{o}C$, migration begins in earnest when water temperature rises above $9\text{-}10^{o}C$. Smolts which are unable to migrate to the sea transform back into parr, and spend an additional year in freshwater.

Atlantic salmon from northeastern United States rivers migrate to north Atlantic waters near Greenland and Labrador. After spending 1-3 years at sea, most return to their natal stream to spawn. Adults that return after one year at sea are known as "grisle", and weigh 1-3 kg. Those returning after 2-3 years at sea are known as "bright salmon", and typically weigh 3-9 kg.

Returning adults typically enter estuarine waters in the spring. Although most migrate upstream in May or June, some remain in estuaries through the summer, and migrate upstream during the fall. Once salmon reach natal streams they tend to remain inactive in deep pools until spawning. Adults do not feed in freshwater.

Restoration Efforts. The Connecticut River is the largest and most important river in southern New England. As shown on Figure 1, the Connecticut River cuts through the center of southern New England and drains a large portion of four states. Historically, the Connecticut River basin supported one of the largest Atlantic salmon fisheries in North America. However, a dam built in 1798 at Turners Falls, Massachusetts prevented adults from reaching upstream spawning grounds, thereby eliminating salmon from the upper basin area. This area included the West River and its tributaries which are located in southeastern Vermont. Efforts were made to restore salmon to the Connecticut River in the mid to late 1800s, but were unsuccessful due to ineffective fish passage facilities and continued dam construction.

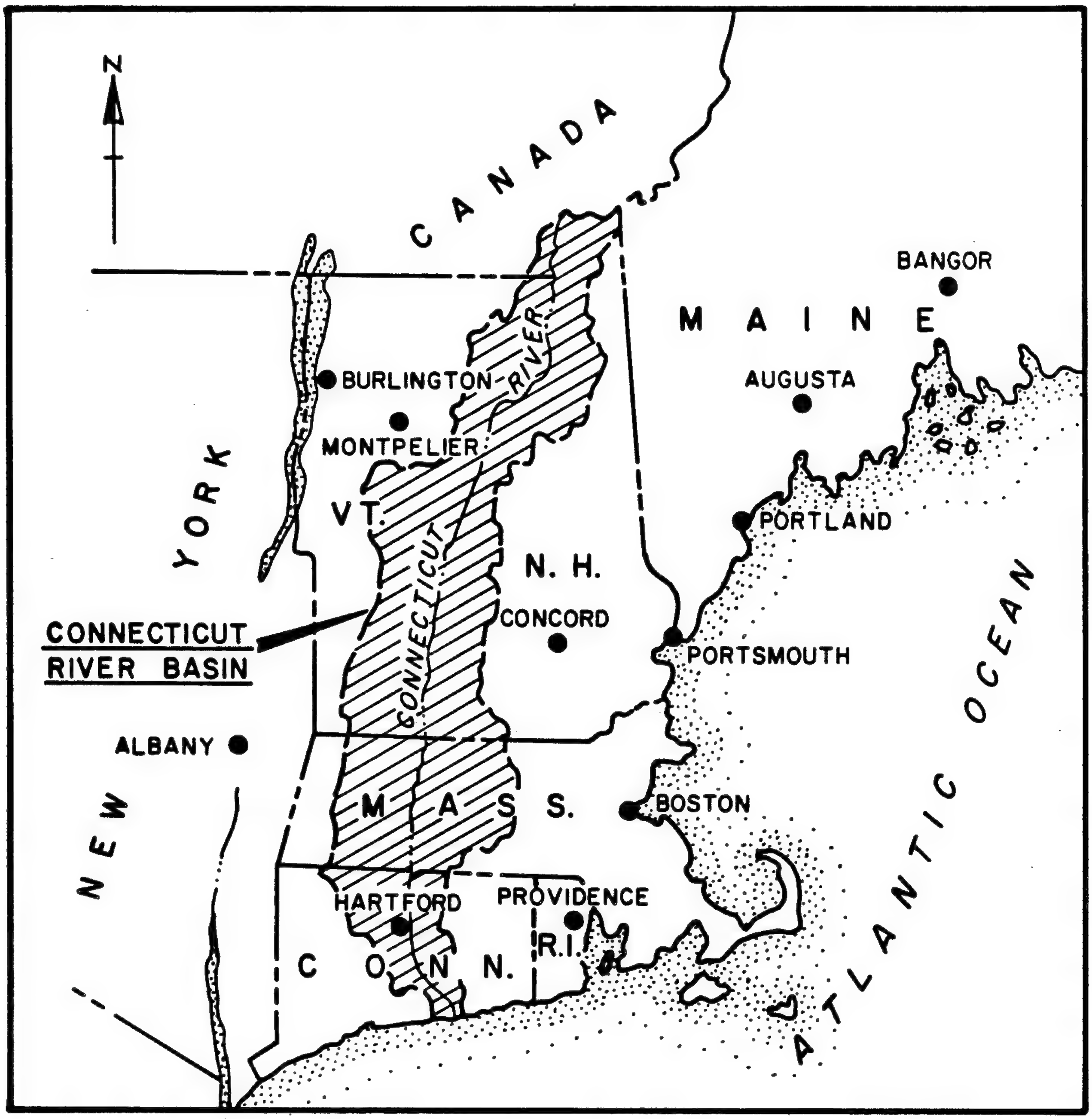
Current restoration efforts were initiated after passage of the Anadromous Fish Conservation Act of 1965 (P.L. 89-304), and establishment of the Connecticut River Anadromous Fish Program in 1967. To date, fish passage facilities have been constructed at five dams along the mainstream of the Connecticut River, including all those downstream of the confluence with the West River. In recent years (1987-1989), nearly 4 million salmon and 1.5 million juveniles (parr and smolts) have been released in the Connecticut River basin. As a result of these and prior stocking efforts, an average of about 210 adult salmon returned to the Connecticut River over the last five years (1987-1991). Virtually all of these salmon are captured at fish passage facilities and are retained for use in the propagation program.

The West River is ranked third among Connecticut River tributaries with respect to potential output of wild salmon smolts. About 80 percent of the wild smolt production habitat is located upstream of Townshend Lake. It is estimated that 43,000 to 90,000 wild smolts can be produced in the West River watershed per year. Given this smolt output, at least 550 adult salmon would be expected to return to the West River each year.

Although fish passage facilities on the Connecticut River allow adult salmon to reach the West River, few spawning adults are currently present in the river. Virtually all salmon migrating to the upper Connecticut River are currently captured at the Holyoke Dam and retained for propagation purposes. A few fish are released above Holyoke, however, and in 1990 and 1991 it is likely that several Atlantic salmon entered the West River. At least one salmon was seen in the pool immediately downstream of Townshend Lake in May of 1990 and two sightings were reported from the West River in 1991. In the next several years much larger returns of adult salmon are anticipated in the Connecticut River. If these projections are correct, substantial numbers of salmon will probably enter the West River. Peak migration of adults into the West River will probably occur between late May and early June, with 85-90 percent of the fish likely to enter the river by the end of July.

No significant natural reproduction of Atlantic salmon currently occurs in the West River. Large numbers of fry, however, have been released into the river since 1987. In 1989 about 320,000 fry were released in the basin, with about 60 percent of these released above Ball Mountain Lake. Only limited fry stocking occurs downstream of Townshend Lake. Principal tributary streams stocked are the Winhall River (Cook Brook and Mill Brook), Utley Brook, Ball (Marlboro Brook). A smaller number of smolts are also released below Townshend Lake.

Surveys conducted by the Vermont Department of Fish and Wildlife indicate that fry survival to the yearling parr stage in West River tributaries is generally good. However, no information is yet available concerning the number of out-migrating smolts from the West River.



LOCATION MAP
CONNECTICUT RIVER BASIN

SCALE IN MILES
40 0 40 80

FIGURE 1

FISH PASSAGE PROBLEMS

Fish passage problems at the Townshend and Ball Mountain Lake projects should be viewed as problems encountered by upstream migrating adult salmon and those encountered by downstream migrating juvenile salmon (smolts). Although migrating adult salmon and smolts are able to pass dams on the Connecticut River main stem, the Townshend and Ball Mountain Lake projects present barriers to migration along the West River.

At Townshend Lake, upstream migrating adult salmon cannot pass the dam due to the configuration of the outlet works (See Plate B-3, Appendix B). The 21-foot deep conservation pool is maintained by a weir upstream of the gate structure. Even if adult salmon were able to swim up the 360 foot long outlet conduit, they could not get past the weir. Downstream migrating smolts may also have difficulty passing through the outlet works. Although the channel leading to the weir is well defined, and smolts can find the outlet, the 21-foot drop to the conduit entrance could harm migrating juveniles.

The configuration of the outlet works at Ball Mountain Lake (See Plate B-2, Appendix B) also prevents upstream migration of Adult salmon. These salmon may be able to find and enter the 864 foot long conduit, but high velocities in the conduit and at the gates would prevent passage through the structure. Current reservoir operation procedures would also preclude downstream migration of juveniles. During the spring migration period, the pool at Ball Mountain Lake is maintained at approximately 65 feet. At this depth it would be difficult for smolts to find the outlet, and if they did, the pressure changes at the gate would result in substantial fish mortality. Consequently, neither upstream nor downstream migration of salmon is now possible at Ball Mountain Lake.

PLANNING OBJECTIVE

The objective of this report is to determine the most effective means of providing passage facilities to allow upstream migration of adult Atlantic salmon and downstream migration of juvenile salmon at the Townshend and Ball Mountain Lake projects. Items essential to developing the best plan are:

- Maximization of the number of fish to be passed in both the upstream and downstream directions.
- Maintaining the viability of the individual fish during passage.
- Concensus between the Corps of Engineers and Fish and Wildlife Agencies.
- Economic efficiency.
- Minimization of adverse environmental impacts.

SECTION III

PLAN FORMULATION

MEASURES AVAILABLE TO ADDRESS THE FISH PASSAGE PROBLEM

Based on the problems encountered by migrating salmon, measures available to address the passage problem have been divided into two categories; solutions to upstream passage problems and solutions to downstream passage problems.

Upstream passage alternatives include the following; (1) installation of a fish ladder or elevator, and (2) construction of a fish trap and truck facility. Modification of current operation procedures at either dam would not be effective due to the configuration of the outlet works at the projects.

Alternatives for downstream passage include modifying current operation procedures, modifying the outlet works or a combination of these alternatives. A trap and truck facility to catch and transport migrating smolts to a point below one or both projects is also a potential solution.

UPSTREAM PASSAGE ALTERNATIVES AND EVALUATION

To provide an effective and efficient means of allowing adult salmon to pass the Townshend and Ball Mountain dams, installing fish ladders or elevators, or constructing a fish trapping facility were investigated. However, early in the investigation, it was determined that installing fish ladders or elevators would be costly due to the difficulty of design and the need to modify existing structures at both projects. Studies by the U. S. Fish and Wildlife Service and others have determined that adult salmon begin entering the Connecticut River during late April and early May, and although the timing of the salmon runs is variable, nearly 90 percent of each years run has been completed by the first week of July. Fish ladders or elevators must therefore be designed to provide maximum passage during a time when flood control operations cause fluctuating pool levels. Installing a fish ladder or elevator with a variable outlet would require major modifications at each project at considerable cost. Townshend dam is 133 feet high and Ball Mountain dam is 265 feet in height. In addition, a ladder or elevator would be required at each structure whereas a fish trapping facility would only be required at the downstream project, Townshend Lake. Trapped salmon could then be transported by truck and released above both Townshend and Ball Mountain dams. Federal and State fish and wildlife agencies concurred that a fish trap and truck facility is the best solution to upstream passage.

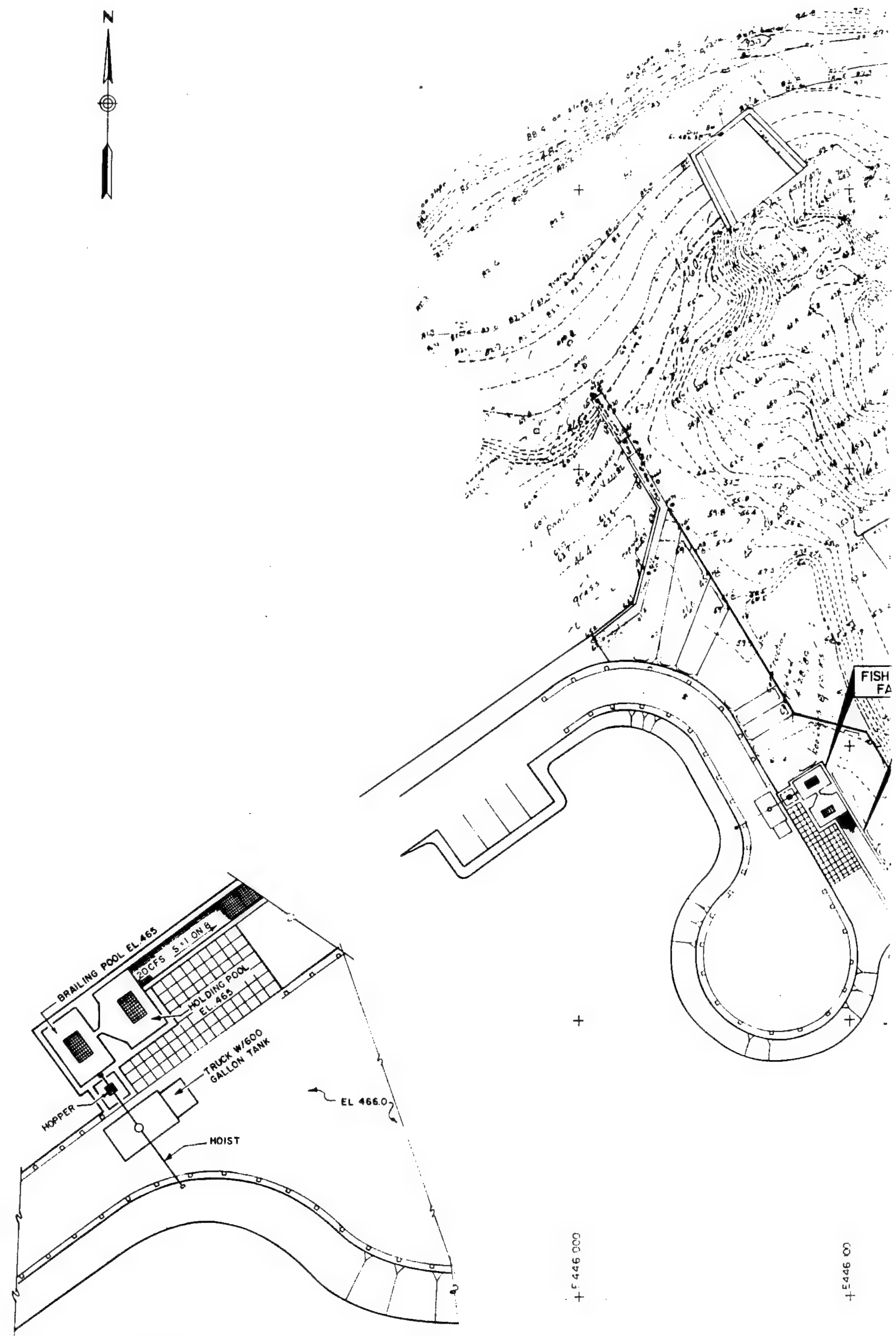
<u>Alternative Fish Trap Plans</u>. A fish trapping facility has three basic elements. They include a fish barrier, a fish ladder and a holding and loading area. The fish barrier prevents upstream migration and directs salmon to a fish ladder which leads to a holding area. A ladder is necessary to elevate fish above potential high river stages. The holding area consists of a holding pool, a brailing pool and a hopper pool. Salmon are taken from the hopper pool and transported via truck to release points.

The location and design of a fish trap facility downstream from Townshend Lake was guided by three major factors. The first is a scouring problem which exists below the outlet conduit. Scouring was considerably worsened as a result of the record 1987 flood and is currently under study. Any facility in this area must therefore be designed to either resist future scour or be located far enough downstream to be out of the potential scour area. The second factor is that any structures be able to pass the maximum downstream reservoir release of 9,000 cfs without damage. The final factor is that the trap facility not interfere with flood control regulation which is the primary function of the reservoir project. In consideration of the above factors and criteria concerning the design of fish trap facilities, three alternative plans were developed. For purposes of clarity, these alternatives are known as Plan A, Plan B and Plan C. The location of each alternative would be different but they all share a similar holding and loading area design.

Plan A (shown on Plate 4) provided for a 125 foot long fish barrier located approximately 300 feet downstream of the outlet structure. This barrier would direct migrating salmon to the entrance of the fishway (ladder) located on the right bank of the river. The proposed fishway would be a 4.0 foot wide, 110 foot long modified Denil-type fishway. The floor slopes 1 vertical to 8 horizontal with the drop in water surface consisting of a series of waterfalls. Fish would pass up the fishway to the holding and loading facilities, located above maximum high water. Water for the fishway and holding facility would be provided by 2 pumps with a capacity of 4500 gallons per minute (10 cfs) each.

After passing up the fishway, fish would enter a holding pool 12.5 feet long, 8.0 feet wide and 6 feet deep, which would have a capacity of about 125 fish. The final fishway weir at the entrance of the pool would be equipped with a finger trap (see Plate 5) to prevent fish from returning downstream. Water to this pool would be supplied through a diffusion grating in the floor. This flow would combine with the flow from the brailing pool to provide the required 10 to 20 cfs necessary to operate the fishway.

The brailing pool would be 12.5 feet long and 8.0 feet wide, and lie immediately adjacent to the holding pool. It would also be supplied with water through a diffusion grating in the floor. This water would flow out of the brailing pool into the holding pool through a connecting gate, thus encouraging the fish to enter the brailing pool when the gate is opened. This opening would be V-shaped in plan to discourage the fish from leaving the brailing pool after entry. The brailing pool would have a false bottom constructed of wood slats which pivot on pins set along the edge nearest the gate leading to the hopper pool. The false bottom could be raised and when it swings up in an arc, the fish would be forced into the entrance to the hopper pool. With the hopper in place, the fish would enter while water flows up through a third diffusion grating in the floor of this pool. The water would then flow out of the entrance gate to the hopper and give added attraction for the fish to enter the hopper. Two vertical combs, composed of round bars spaced to fit between the wood slats of the false floor of the brail, would prevent fish from lodging in the corners of the brail pool when the false floor is tilted up.



ENLARGED PLAN
SCALE: 1" = 10'

FI

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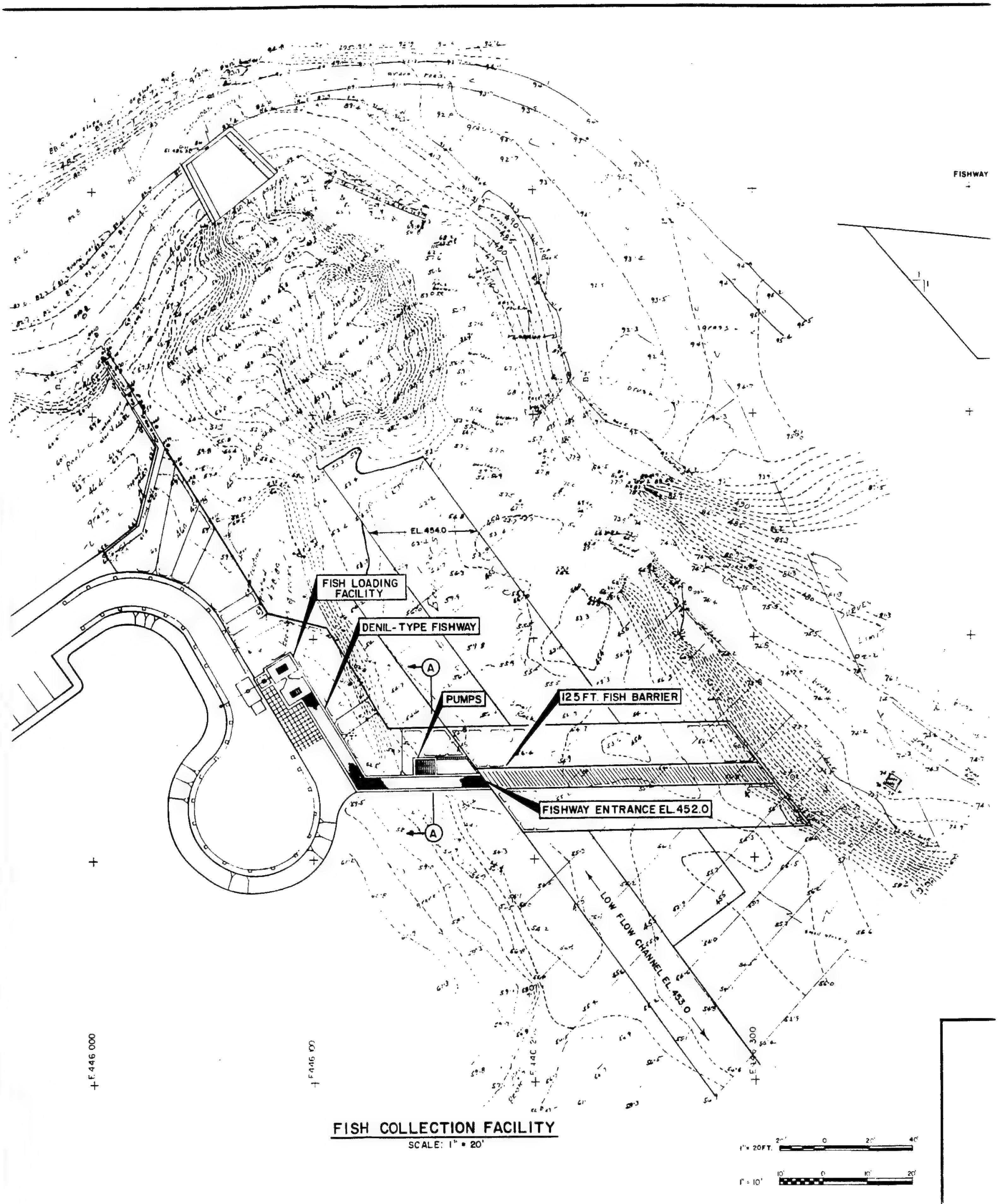
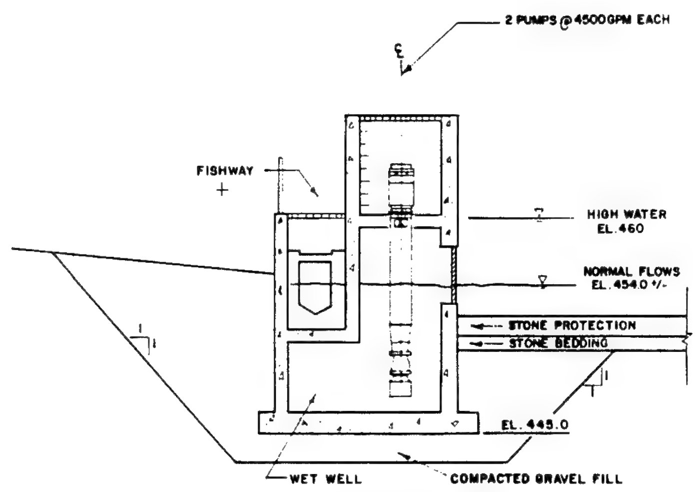
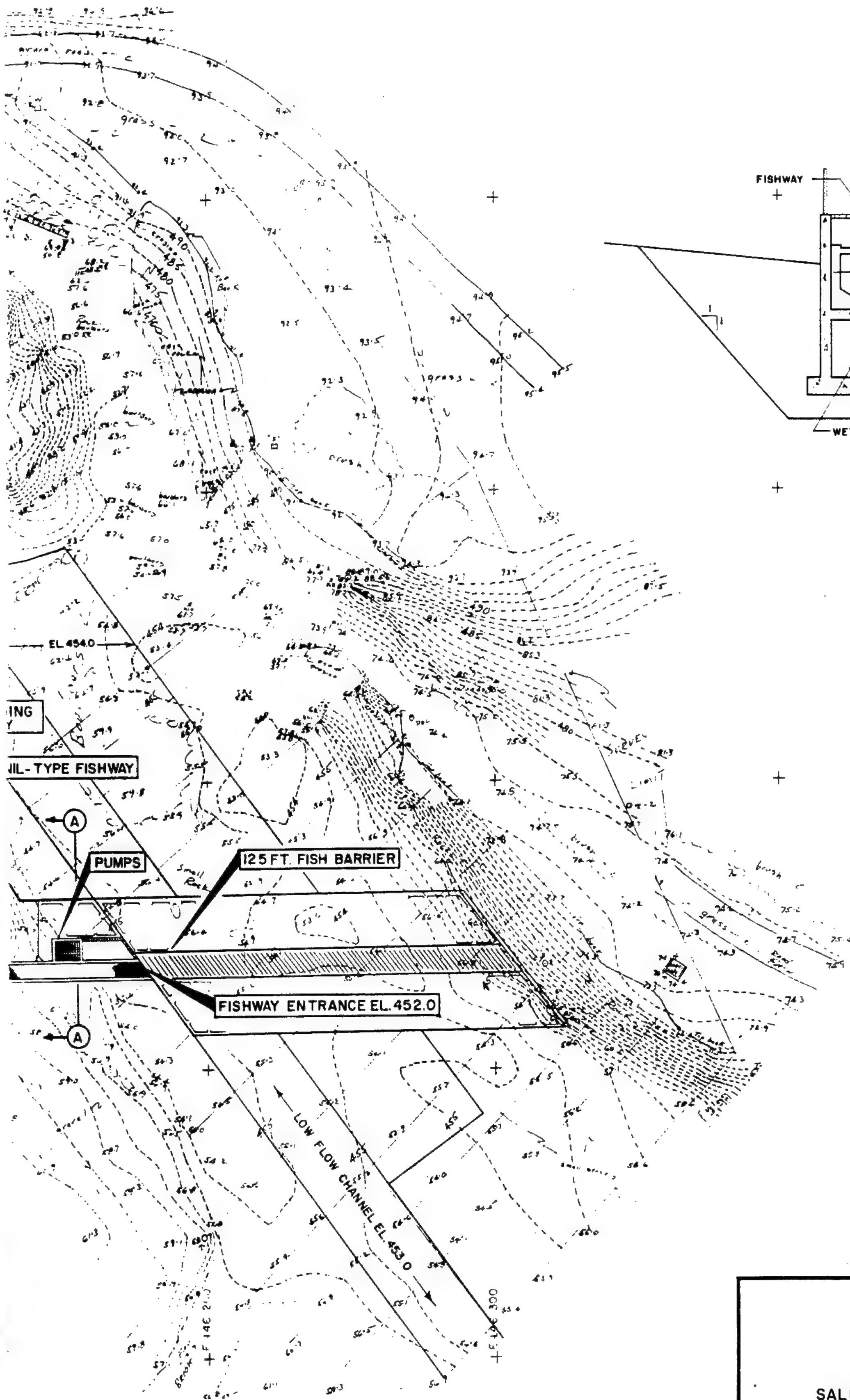


FISH COLLECTION FACILITY

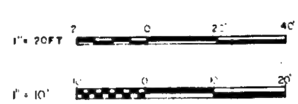
SCALE: 1" = 20'



SECTION A
SCALE: 1" = 5'



COLLECTION FACILITY
SCALE: 1" = 20'



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM MASS

TOWNSHEND LAKE

SALMON RESTORATION PROJECT

FISH COLLECTION FACILITY

PLAN A

PLATE 4

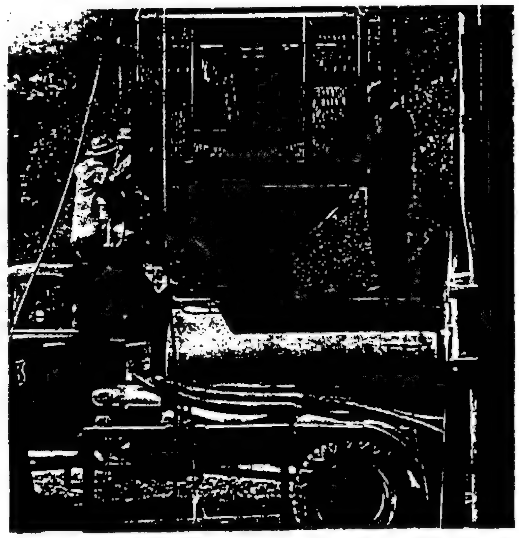
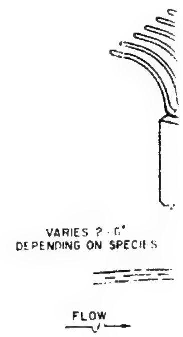
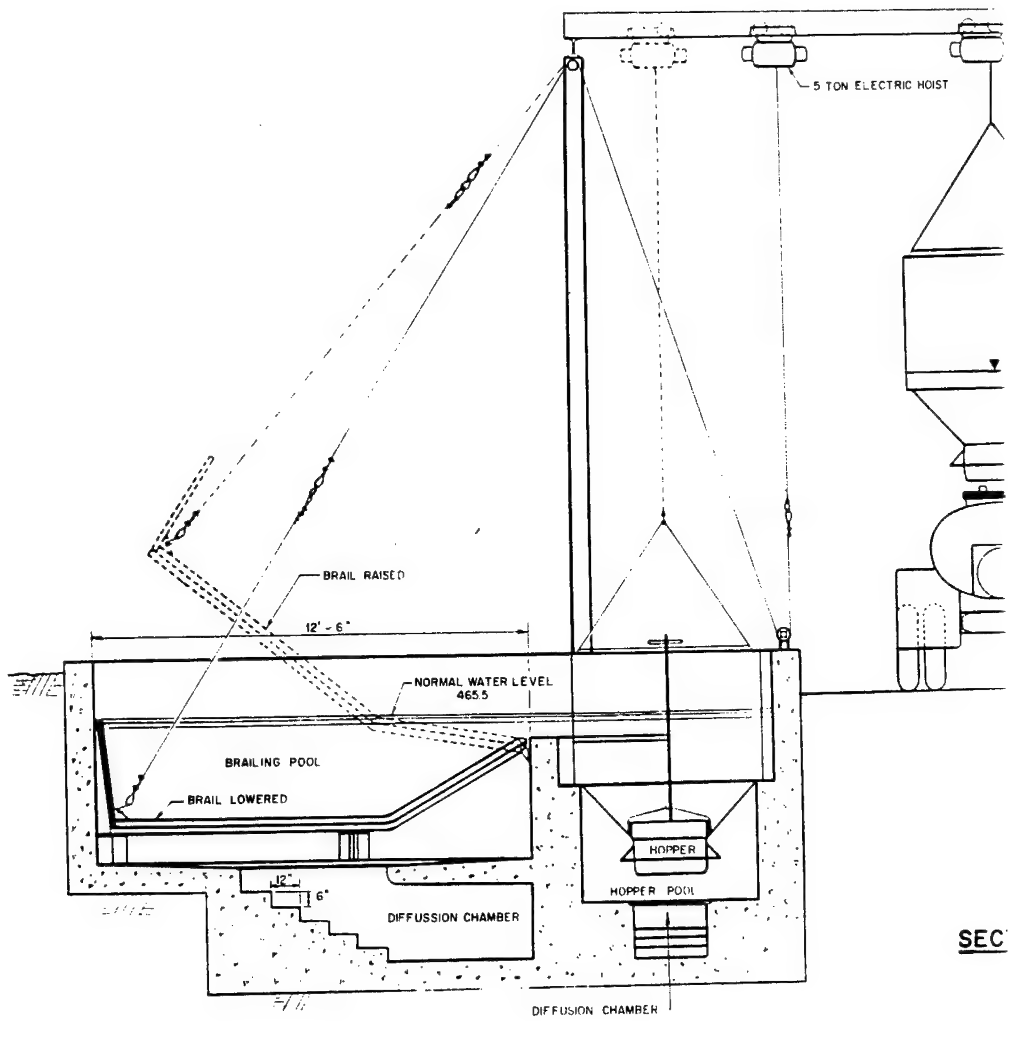


PHOTO: 600 GAL. TANK TRUCK-LOADING FISH FROM HOPPER





SEC

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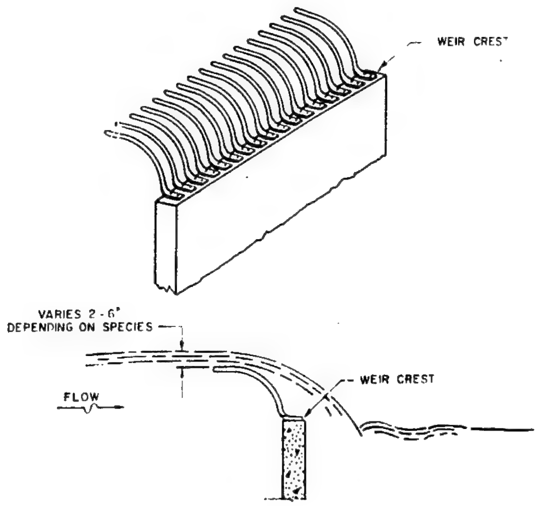
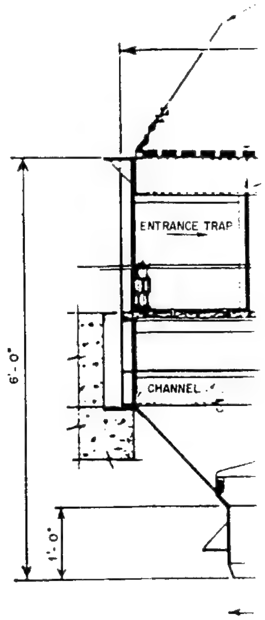
G FISH FROM HOPPER

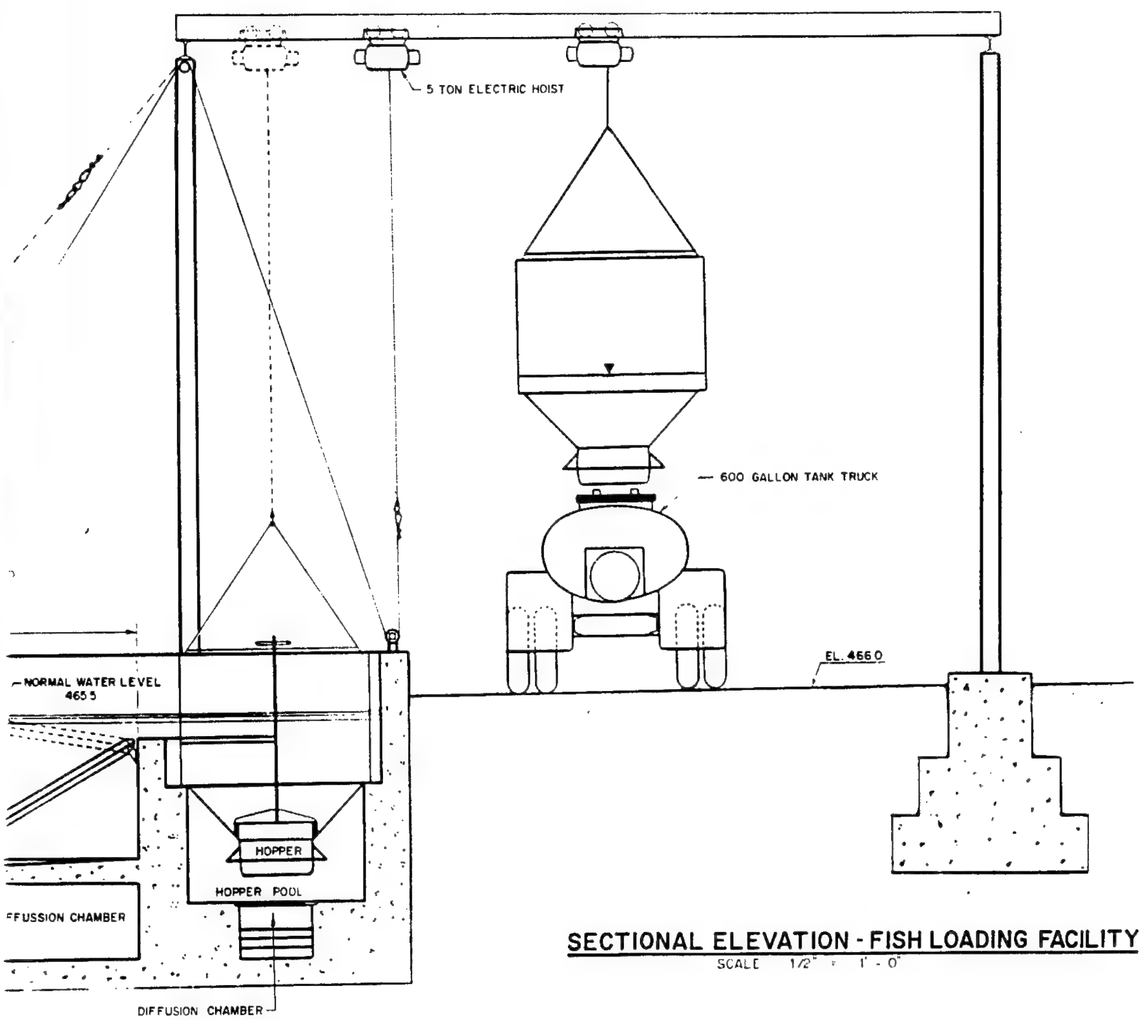


WEIR - DETECTOR DETAIL

N. T. S



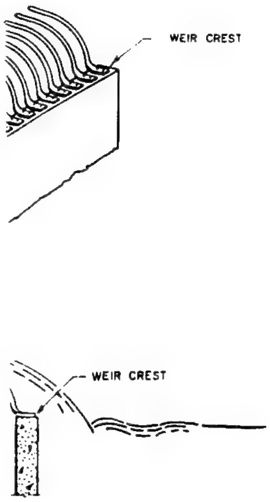
HOP



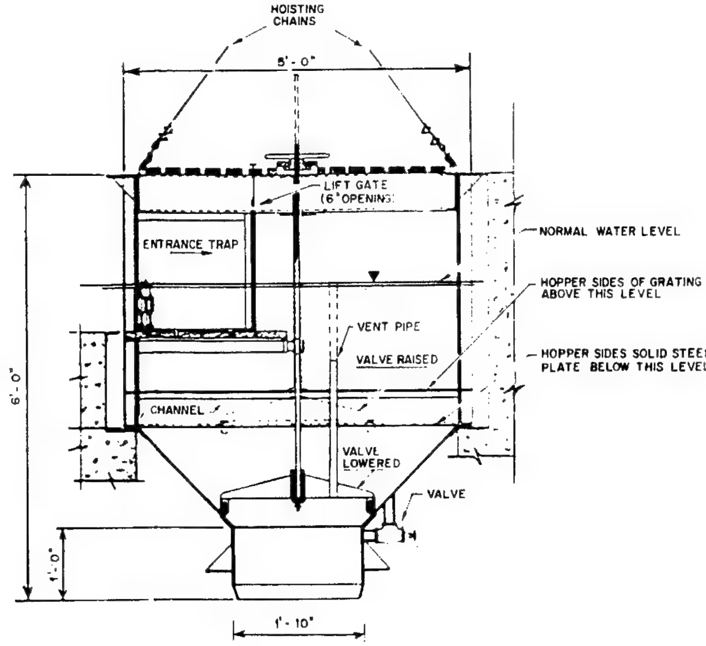
SECTIONAL ELEVATION - FISH LOADING FACILITY

SCALE 1/2" = 1'-0"

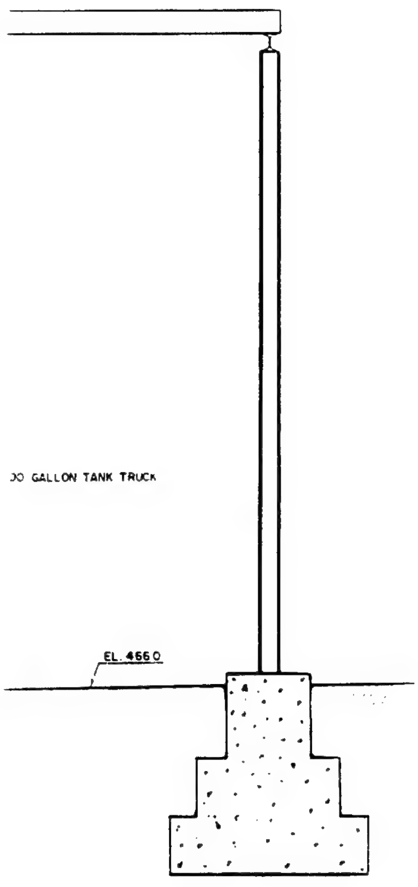
PHOTO: 600 GAL.



)ETECTOR DETAIL
N. T. S



HOPPER DETAIL
SCALE 1" = 1'-0"



LEVATION - FISH LOADING FACILITY
:ALE 1/2" = 1'-0"

PHOTO: 600 GAL. TANK TRUCK WITH QUICK RELEASE GATE

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

TOWNSHEND LAKE

SALMON RESTORATION PROJECT

FISH LOADING FACILITY

SECTIONAL ELEVATION, DETAILS AND PHOTOS

3

After all fish have been cleared from the brailing pool and are in the hopper, the gate and valve in the hopper would be closed and the hopper raised by an electrically driven winch. Salmon would then be transferred to a tank truck. Due to the number of salmon anticipated at Townshend Lake, only one tank truck would be required. With a capacity of 600 gallons and two circulating pumps of 120 GPM each, it would have a capacity of about 80 average-size (7 1/2 pound) salmon. The truck would be equipped with a quick-acting release gate to permit salmon and water to be sluiced out very rapidly at the release site.

Plan B (shown on Plate 6) included a fish ladder and holding area located on the right bank of the river immediately downstream of the outlet structure. To prevent salmon from entering the outlet conduit, a steel rack would be placed across the downstream face of the outlet structure. The rack, approximately three (on Plate 6) feet high, would be raised for debris removal and during times when flows exceed 1500 cfs. This rack would direct migrating salmon to one of two entrances to the fish ladder. For lower flows the entrance near the outlet structure would be used and during higher flows the other entrance would be utilized. Changing the fishway entrance would be accomplished with sluice gates located in the fishway. The fishway would also be designed to prevent further scour of the right bank in this area. The operation and design of the fish holding and loading area is the same as Plan A.

The third plan, Plan C (shown on Plate 7) is very similar to Plan B except that the fishway and holding area are located on the left bank of the river. In addition, due to the steep rock embankment on the left bank, these facilities are located on excavated bedrock. To minimize the amount of rock excavation for this plan, vehicular access is not provided to the holding area. Fish would be transferred from the holding area by hoist to a vehicular parking area situated about 25 vertical feet above the holding area. The fish barrier would be the same as Plan B and the design of the holding area would be the same as Plan A.

<u>Evaluation of Fish Trap Plans</u>. Evaluation of alternative fish trap plans involved consideration of several factors. Foremost among these was the potential effectiveness of the plans to trap upstream migrating salmon. Although a traditional benefit to cost analysis was not necessary because the benefits of project features for fish and wildlife enhancement are deemed to be at least equal to their cost (Section 907 of the Water Resources Development Act of 1986), the effectiveness of each plan, as compared to its cost, was used as a measure of economic efficiency. Other major factors included; potential impacts to the existing project, principal environmental impacts, and operation and maintenance of the trap facility.

The first factor evaluated was the overall effectiveness of the trapping facility. Plan A would be very effective in guiding salmon to the fish trap and minimizing any delay in their upstream migration. Once salmon encounter the barrier, they would move along the barrier to the fishway. Movement across the river is enhanced by the angle of the barrier which directs fish to the fishway entrance located at its upstream end. Furthermore, since salmon are attracted to relatively higher flows, the velocity of flows exiting the fishway would be greater than that of the river. The overall effectiveness of Plans B and C would be very

similar to each other. The barrier would prevent entrance to the outlet conduit, causing salmon to seek an alternative migration route. However, considering the swirling waters in the outlet pool, fish may be disoriented and may not easily find the fishway entrance. This may be a more serious problem when the downstream fishway entrances are used during high flows, since there are no features to help orient fish towards these entrances. The potential delay caused by these concerns and the possibility that some fish may turn back if disoriented, reduce the effectiveness of plans B and C.

The cost of each fish trap alternative is presented in the following tabulation:

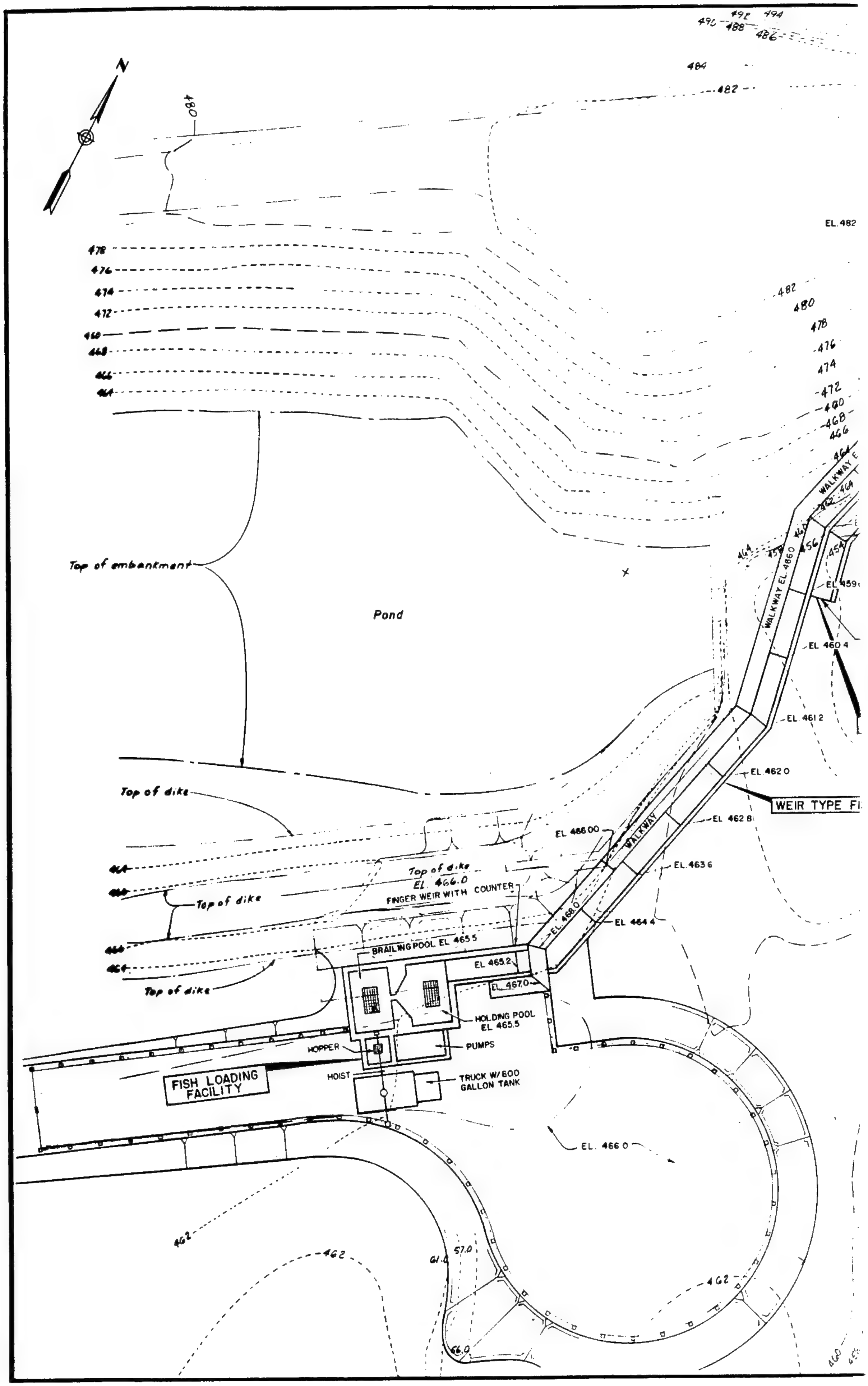
Alternative	Cost
Plan A	$770,000
Plan B	$760,000
Plan C	$710,000

As shown above, the costs of these plans are very similar with Plan A being the most expensive at $770,000. Detailed estimates of these costs are shown in Appendix E.

The next factor evaluated was the potential impact on the existing Townshend Lake Project. Since Plans B and C are located adjacent to and within an area of recent scour, there is concern regarding the limit of future scouring. Ongoing and future studies of the scouring problem may result in the need to install a stilling basin at the outlet. Any existing fish trap would have to be incorporated into the stilling basin design, which could impact the function of both facilities. In addition, there are serious concerns that a fish barrier located at the outlet works could impede discharges from the outlet works during a major flood. High velocities, debris accumulation and potential cavitation are likely causes of operation and maintenance problems for a rigid fish barrier located at the conduit outlet. Plan A is located further downstream and should not impact the existing project.

Construction of Plan A would cause minor short and long-term impacts to aquatic habitat. Riparian areas would also be developed and although most of this area was previously disturbed, several hundred square feet of vegetated area would be lost. Plans B and C would entail lesser impacts to aquatic and riparian habitat. These plans would still require work within the river channel, but riparian impacts would be limited to highly disturbed, unvegetated areas.

Operation and maintenance needs for all alternatives would be very similar. Lack of vehicular access to the holding and transfer area in Plan C, however, would complicate some operation and maintenance functions. Transferring fish to the tank truck would be more time consuming and replacing large items such as the pumps would be more difficult. Other than this difference, the project life and replacement requirements are expected to be the same for all alternatives.


N
Top of embankment
Pond
Top of dike
Top of dike
EL. 466.0
Top of dike
Top of dike
FINGER WEIR WITH COUNTER
BRAILING POOL EL 465.5
EL 465.2
EL 467.0
HOLDING POOL
EL 465.5
PUMPS
HOPPER
HOIST
TRUCK W/ 600
GALLON TANK
FISH LOADING
FACILITY
EL. 466.0
EL 466.00
EL 468.0
WALKWAY
WALKWAY EL 466.0
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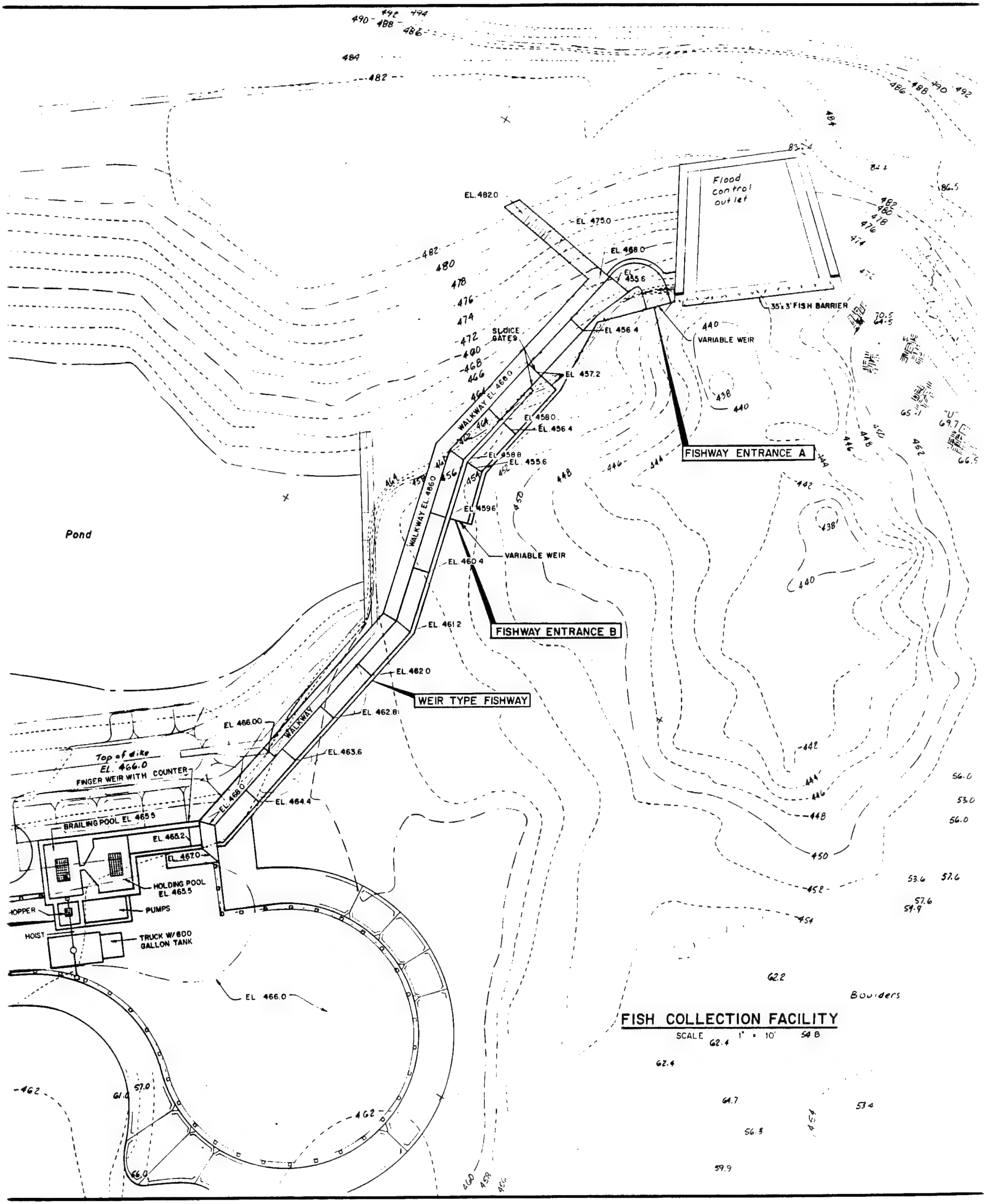
WEIR TYPE FI



Flood control outlet
EL. 482.0
EL. 475.0
EL. 468.0
EL. 455.6
35' x 3' FISH BARRIER
EL. 456.4
VARIABLE WEIR
SLUICE GATES
EL. 457.2
WALKWAY EL. 468.0
EL. 458.0
EL. 456.4
FISHWAY ENTRANCE A
EL. 458.8
EL. 455.6
WALKWAY EL. 466.0
EL. 459.6
VARIABLE WEIR
Pond
EL. 460.4
FISHWAY ENTRANCE B
EL. 461.2
EL. 462.0
WEIR TYPE FISHWAY
EL. 466.00
WALKWAY
EL. 462.8
Top of dike EL. 466.0
EL. 463.6
FINGER WEIR WITH COUNTER
EL. 468.0
EL. 464.4
BRAILING POOL EL. 465.5
EL. 465.2
EL. 467.0
HOLDING POOL EL. 465.5
HOPPER
PUMPS
HOIST
TRUCK W/600 GALLON TANK
EL. 466.0
Boulders
FISH COLLECTION FACILITY
SCALE 1" = 10'

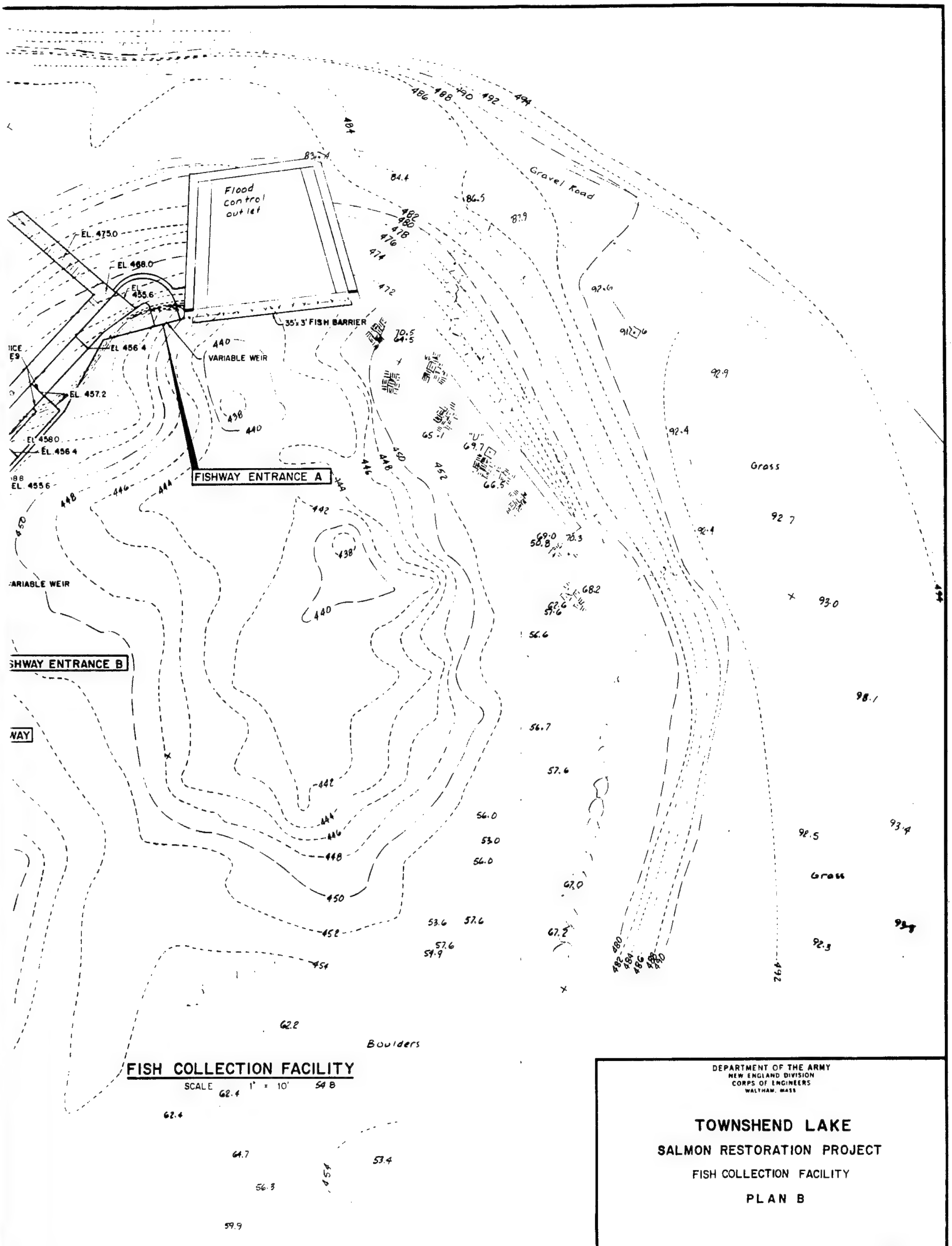
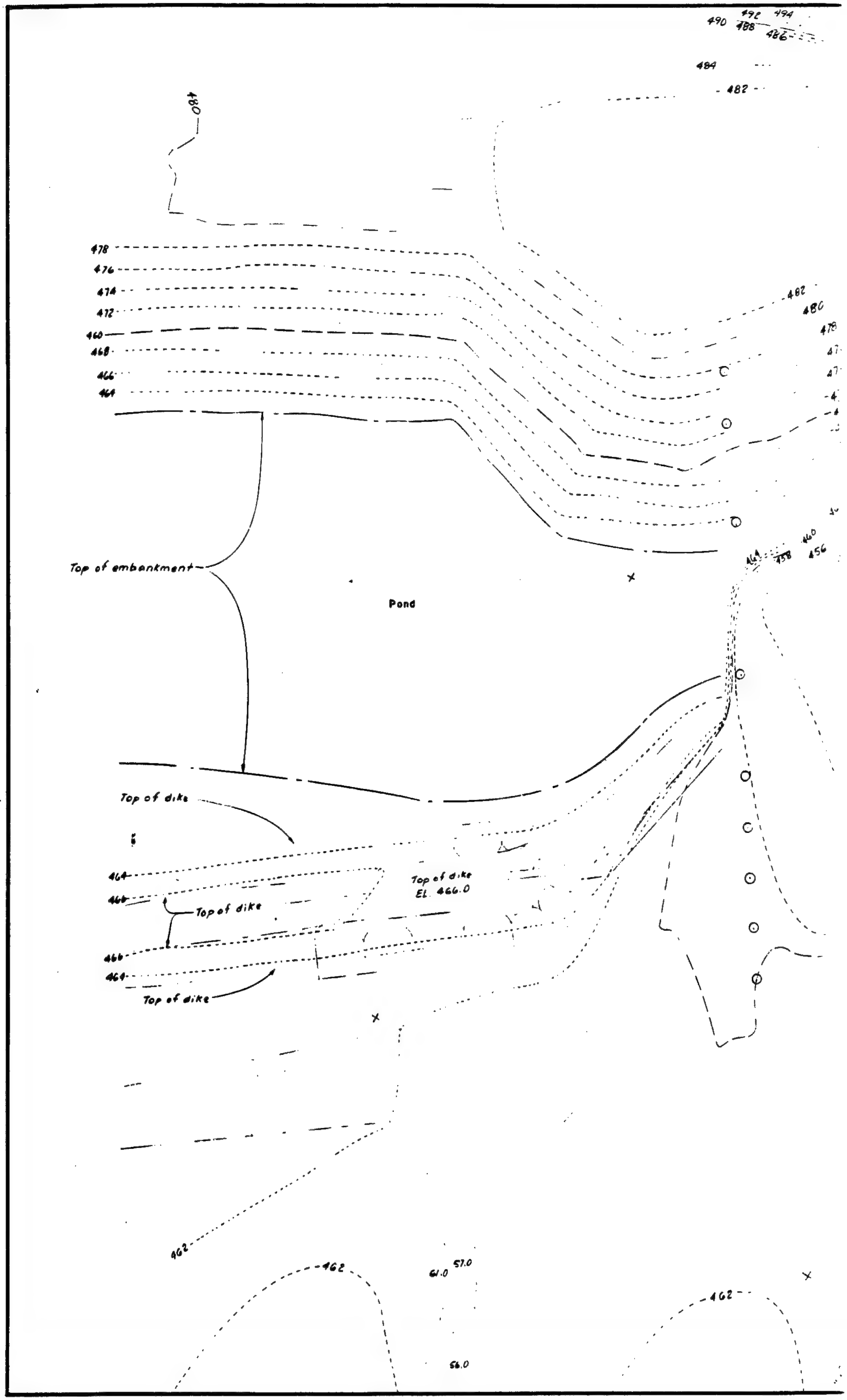

Flood control outlet
Gravel Road
35'x3' FISH BARRIER
VARIABLE WEIR
FISHWAY ENTRANCE A
EL. 475.0
EL. 468.0
EL 455.6
EL 456.4
EL. 457.2
EL 458.0
EL. 456.4
EL. 455.6
Grass
FISHWAY ENTRANCE B
Boulders
FISH COLLECTION FACILITY
SCALE 1" = 10'
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS
TOWNSHEND LAKE
SALMON RESTORATION PROJECT
FISH COLLECTION FACILITY
PLAN B

PLATE 6

(3)



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456
Top of dike
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466
Top of dike
EL. 466.0
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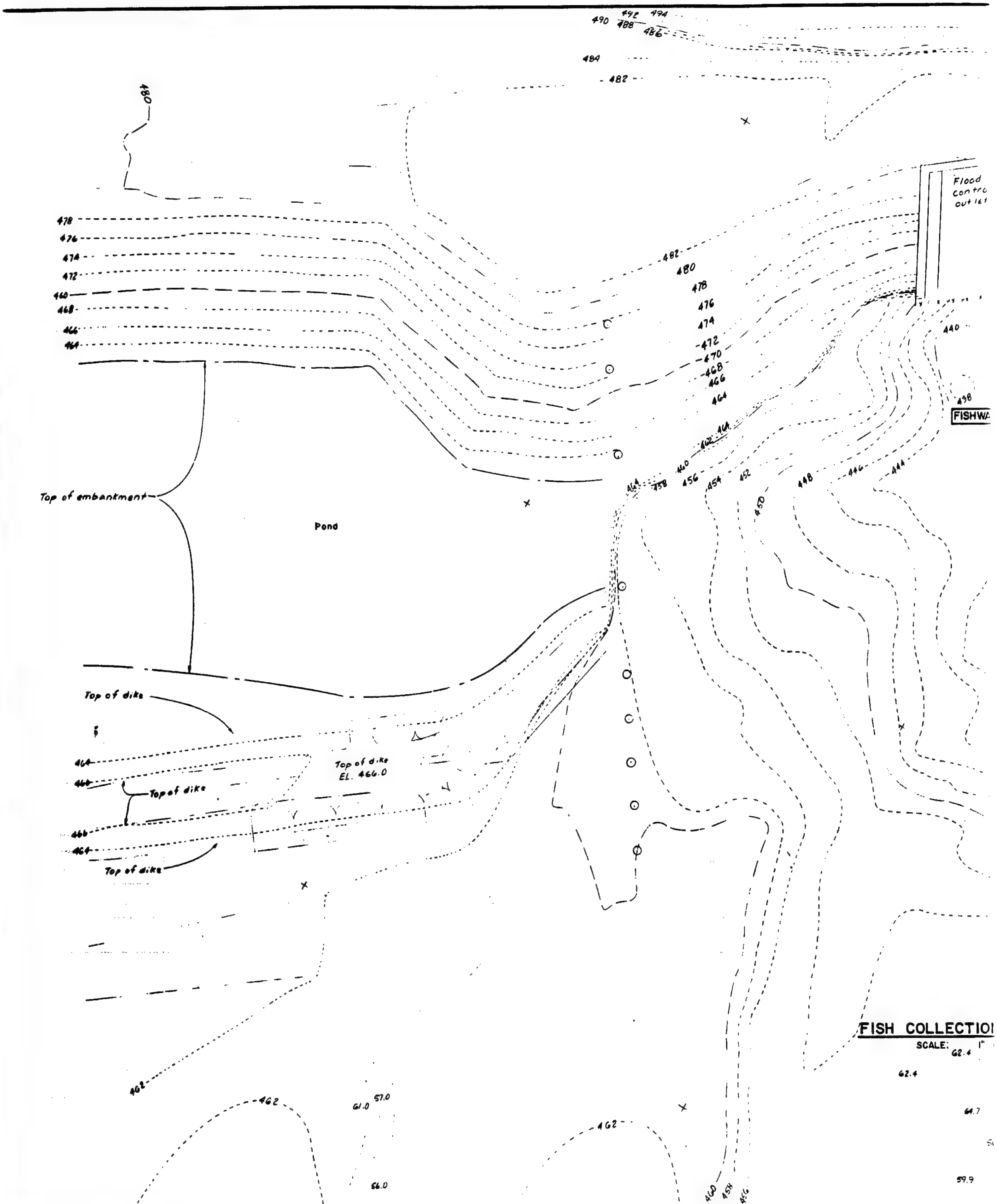
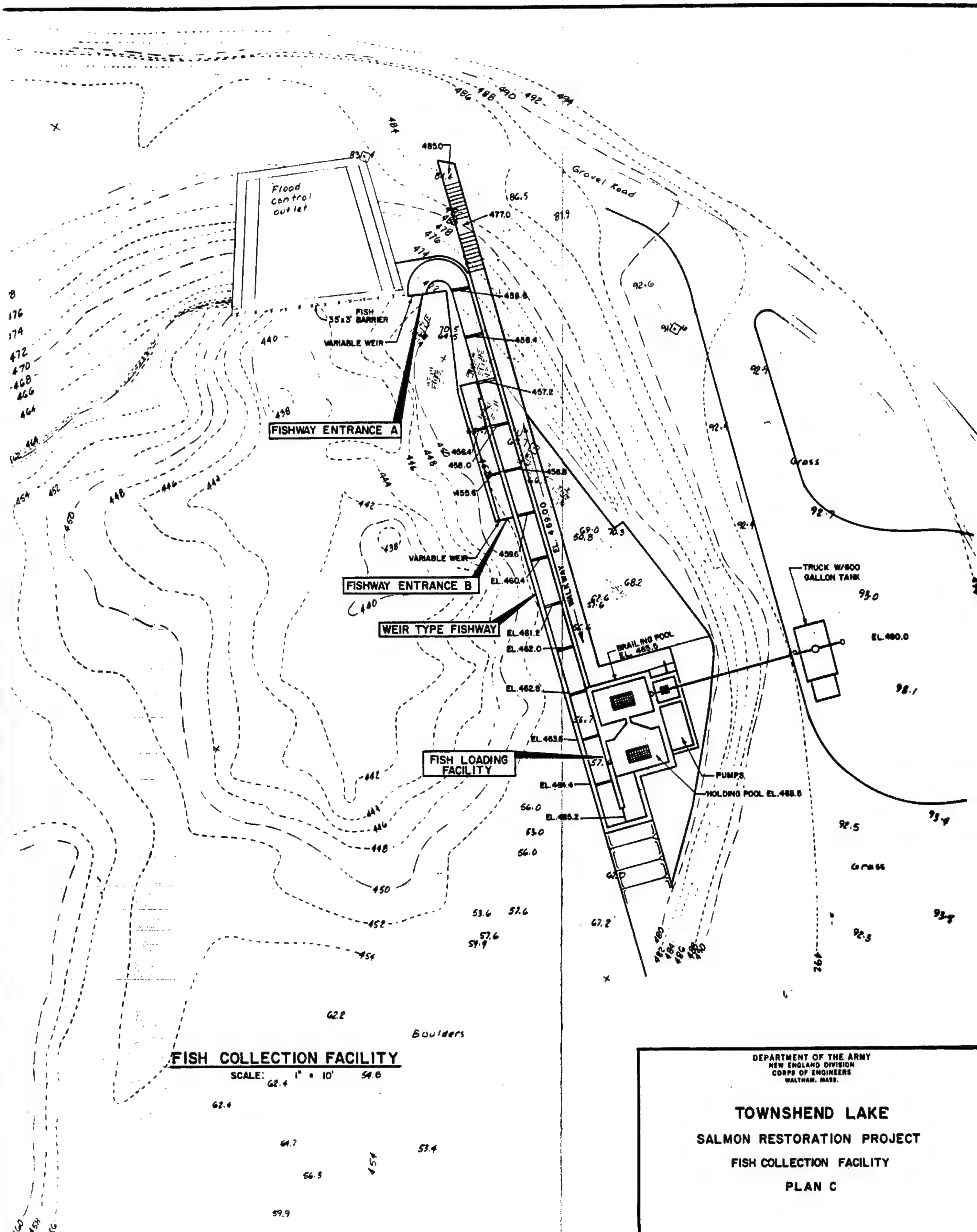
Top of dike
462
462
61.0
57.0
462
56.0

(1)



Flood control outlet
FISHWA
Top of embankment
Pond
Top of dike
Top of dike EL. 466.0
Top of dike
Top of dike
FISH COLLECTIO
SCALE: 1"

(2)



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

TOWNSHEND LAKE

SALMON RESTORATION PROJECT

FISH COLLECTION FACILITY

PLAN C

Based on the previous evaluation, Plan A is considered to be the best overall plan. Its higher cost and somewhat greater impact on riparian habitat are more than offset by its effectiveness in trapping migrating salmon. It is considered the most economically efficient because it is able to trap migrating salmon with a minimum of delay and loss, with only a small increase in cost. In addition, Plan A should not impact the operation and maintenance of the existing Townshend Lake project. Federal and State fish and wildlife officials involved in the study concurred with this conclusion.

DOWNSTREAM PASSAGE ALTERNATIVES AND EVALUATION

Initial discussion and evaluation of potential solutions to the downstream passage problem with interested agencies and officials determined that trapping migrating smolts and trucking them downstream should only be considered as a last resort. Traps would be required at each dam at considerable expense and the effectiveness of such a plan is questionable. Measures to allow downstream passage, therefore, concentrated on changing current operation of the projects, modifying the outlet works, or a combination of these measures.

Development of a plan for downstream passage at Townshend Lake was based on information previously developed by the U. S. Fish and Wildlife Service. Migrating smolts can easily find the outlet of the lake because the channel leading to the outlet works is well defined. The outlet works consists of three gates. A weir located upstream of the center gate controls the pool level during low flows and, as the need arises, the side gates are opened to maintain the pool level or make flood control releases. Since migrating smolts are expected to pass through the side gates with little difficulty, the problem became one of easing their passage over the weir and reducing the effects of the 21-foot drop to the outlet culvert. To accomplish this it is proposed to notch a portion of the weir to provide additional water depth during low flows and to construct a small weir within the outlet structure. This small weir would form a "splash pool" to cushion the smolt's landing after passing over the 21-foot high weir. It would also reduce the overall height of the fall. The impact of these modifications on the outlet works is considered negligible. This will be confirmed during detailed design.

Providing downstream passage at Ball Mountain Lake involved the evaluation of existing operational procedures (presented in detail in Appendix F). A permanent pool of 25 feet is maintained to facilitate gate operations during the winter months, and during the spring the pool level is raised to 65 feet for the recreation season. As previously stated, this 65 foot pool is normally in place during the spring migration period, and if smolts were able to find the outlet at the bottom of the pool, they would most likely not survive the pressure changes at the gates. To correct this condition, either a surface outlet or a shallower pool is required. Constructing a weir upstream of the gates to provide a surface outlet was considered, but eliminated due to its high cost when compared to the other alternative, and its impact on the overall cost of providing passage facilities. Consequently, the only viable alternative was to lower

the pool level during the primary smolt migration period (end of April - June 1). Of the various pool levels considered, a pool level of 25 feet was selected because smolts will sound to this depth and it is the same as the level of the permanent pool. Lowering the pool further could result in an adverse impact on aquatic life in the West River due to erosion and downstream transport of accumulated sediment in the reservoir. The existing recreational fishery in Ball Mountain Lake might also be adversely affected.

To test the effectiveness of the above downstream passage measures, modifications were made at the projects to approximate these measures and a contract was entered into with the U. S. Fish and Wildlife Service (USFWS) to conduct a smolt migration study. Modifications included lowering the Ball Mountain pool to 25 feet, and placing wooden beams in the stop log slots upstream of Townshend Lake's center gate to form a splash pool. Notching the outlet weir at Townshend Lake, however, was not possible during this study.

Once these operational and structural changes were made in early May 1990, the USFWS study of out-migrating hatchery reared smolts was conducted. Since the primary area of concern to fishery agencies is the potential delay caused by the dams, radio telemetry was selected as the method to obtain data on out-migrating smolts. Hatchery reared smolts were used in place of stream reared smolts because of their availability. An external transmitter was attached to each smolt and their movement after release was recorded by both fixed and portable radio telemetry receivers. Fixed receivers were used to provide an automated continuous record of smolts passing through the two dams and portable receivers were used to provide supplemental data on smolts above and below the dams.

Smolt releases were made on May 16, 1990 and May 23, 1990; a time of year that stream reared smolts would be expected to be migrating from the West River. Each release of smolts above Ball Mountain dam consisted of ten (10) smolts, while each release above Townshend dam consisted of five smolts. Of the thirty (30) smolts released, twenty nine (29) were detected below the dam they were released above. All smolts that passed through the dams they were released above did so within eleven hours, and twenty (20) passed within three hours. In addition, of the nineteen (19) that passed Ball Mountain dam, twelve (12) subsequently passed through Townshend dam. Four (4) were from the May 16 release and eight (8) were from the May 23 release.

The USFWS Report, included as Appendix C, concluded that "Under the flow and operating conditions existing at the times of the releases, hatchery reared smolts encountered only slight delays."

Consequently, with the proposed modifications in place, the delay encountered by migrating smolts is not considered significant. Although it was doubtful that the twelve (12) smolts that passed through both dams were injured or dead and were washed the ten miles from one dam to the other, it was determined that additional studies were necessary to confirm the physical condition of smolts passing through Ball Mountain Lake.

If these studies determine that smolts passing through the project suffer substantial mortality, a reduction in pool stage, possibly to zero, may be necessary during the outmigration period. The results of these mortality studies and operational experience will ultimately determine the best pool level. However, based on available information concerning smolt passage, and potential impacts on downstream water quality and the Lake's recreational fishery, lowering the pool to 25 feet is presently considered the best plan for allowing downstream passage at Ball Mountain Lake.

During the process of this study it was also determined that maintaining a 25 foot pool at Ball Mountain Lake required 24-hour surveillance. The rapid runoff characteristics of the contributing watershed and lack of storage area at lower pool stages, required frequent adjustment of the gate settings. To solve this problem, it is proposed to automate one of the three gates. To keep outflows within acceptable levels, the limit of automatic adjustment would be set by New England Division's Reservoir Control Center. However, if necessary the gates could be controlled through an on site operator.

It is estimated that modifications at Townshend Lake would cost $45,000 and modifications at Ball Mountain Lake would cost $55,000.

RECOMMENDED PLAN BASED ON CONCEPT STUDIES

Based on the previous evaluation of alternatives, it was determined that upstream and downstream passage could best be achieved by the following measures:

Upstream Passage: Construct a fish trap facility downstream from Townshend Lake. Adult salmon collected at this location would be trucked to release points above both Townshend and Ball Mountain dams.

Downstream Passage: Modify the outlet works at Townshend Lake by notching a portion of the outlet weir and constructing a small weir within the outlet structure upstream of the center gate which would form a splash pool to cushion the smolts landing after passing over the outlet weir.

Modifications at Ball Mountain Lake would include reducing the pool to 25 feet from the end of the last weekend in April to June 1 and automating one of the outlet gates to assist in maintaining this 25 foot pool.

The total estimated construction cost of these measures was $925,000, as shown in the following tabulation:

Item	Cost
Fish Trap Facility	$770,000
Outlet Modifications at Townshend Lake	45,000
Automated Gate at Ball Mountain Lake	55,000
Construction Supervision and Administration	55,000
Total Cost	$925,000

Due to the high level of interest in providing Atlantic salmon passage facilities along the West River, a draft report outlining the findings which led to selection of this plan was sent to Headquarters, U.S. Army Corps of Engineers for early review. This review determined that: (1) the report should be finalized including completion of environmental documentation; and (2) the conceptual design and level of detail presented in the report was considered adequate as a basis for proceeding with advanced planning, engineering and design, including plans and specifications. Based on this guidance, completion of this Specific Project Report, and preparation of Plans and Specifications were conducted simultaneously. These detailed studies resulted in several revisions to the recommended plan. These revisions are described in the following section.

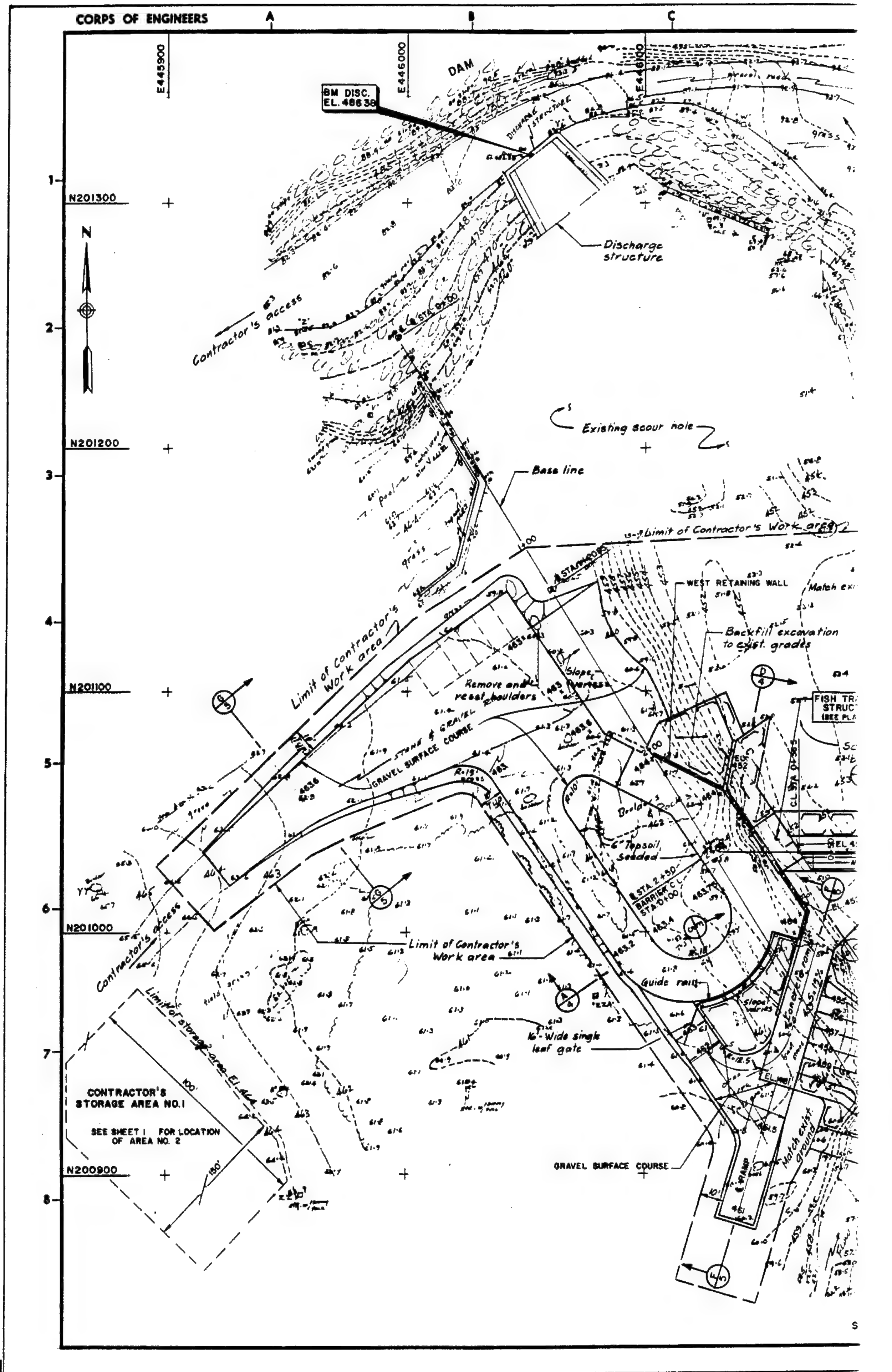
RECOMMENDED PLAN AS REVISED BASED ON ADVANCED PLANNING, ENGINEERING AND DESIGN

As planning proceeded and design details were developed, it became apparent that the recommended plan required revision. Concerns about the plan's overall cost, and the performance of the fishway under low flow conditions arose during formulation of detailed plans. Further analysis and coordination determined that an in-stream trap and holding area could be substituted for the fishway and holding area. The resulting plan, as shown on Plates 8 thru 11, is a significant improvement over the original plan. It is less costly to construct and operate because it eliminates the need for a fishway and associated pumps, and it will perform more reliably during low flows.

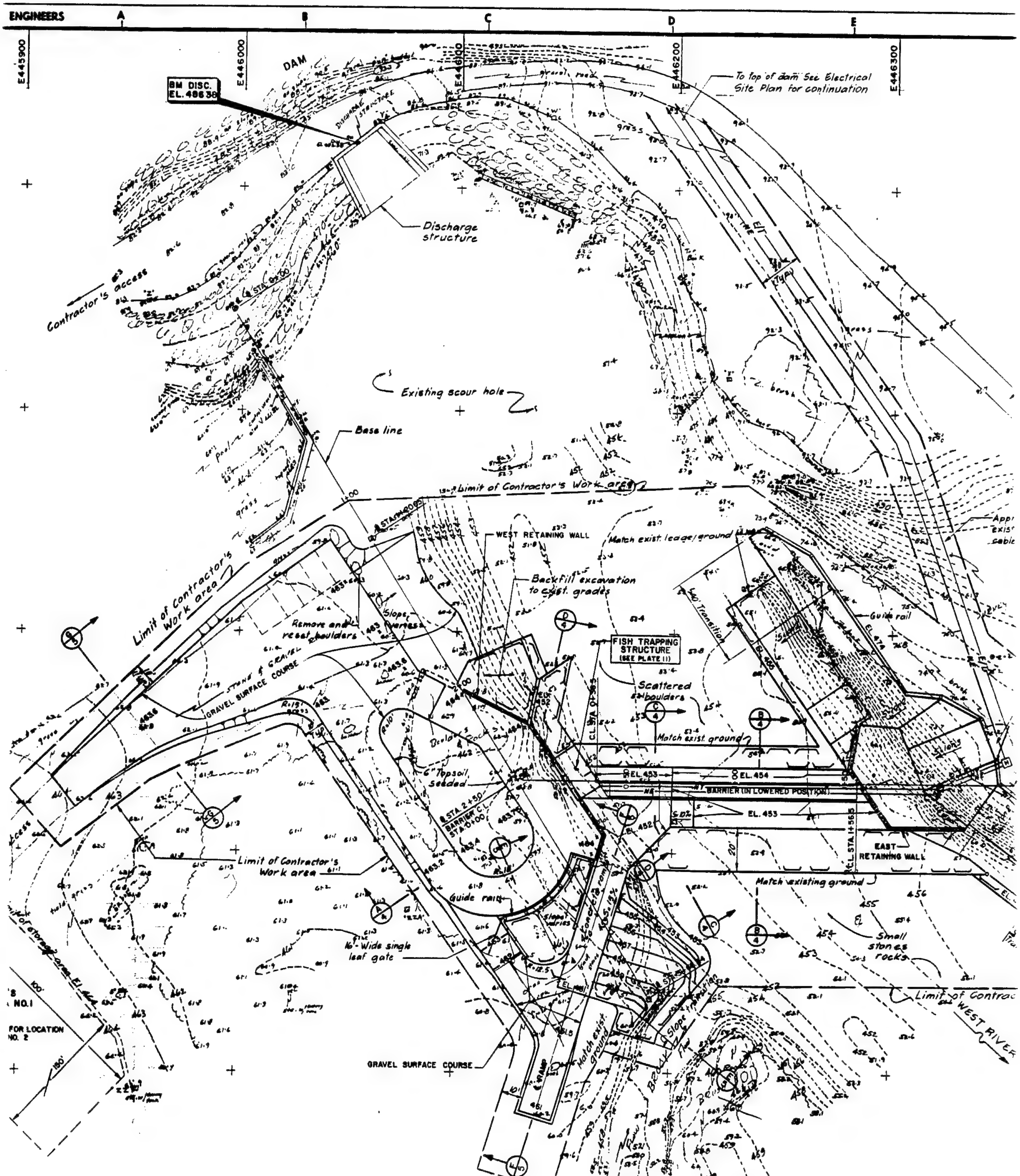
Additional studies were also conducted to determine the physical condition of smolts after passing through Ball Mountain dam with a 25 foot pool. A second contract was entered into for the USFWS to conduct the required study.

To obtain the desired information and gather data concerning the travel times for both hatchery reared and wild smolts, it was decided that paired releases of hatchery and wild smolts would be made. To assess the condition of smolts that passed through Ball Mountain Lake, releases were made at Winhall Brook (3.5 miles upstream of Ball Mountain dam) and at Cobb Brook (0.35 miles downstream of the dam). Each smolt was tagged and movement of individual fish was tracked by both fixed and portable receivers. As a further control, dead (recently sacrificed) smolts were also placed in the stream at Cobb Brook, and their downstream movement was compared to that of the live smolts. Prior to the study, the pool at Ball mountain Lake was lowered to 25 feet and a splash pool was formed at the Townshend Lake outlet works by placement of stop logs.

Smolt releases were made on May 8, 1991 at both Winhall and Cobb Brooks. Fifteen wild and 15 hatchery smolts were released at each location. In addition, 13 dead smolts were placed in the river at Cobb Brook.


CORPS OF ENGINEERS
A
B
C
E445900
E446000
E446100
DAM
BM DISC.
EL. 486.38
Discharge structure
N201300
N201200
N201100
N201000
N200900
1
2
3
4
5
6
7
8
N
Contractor's access
Existing scour hole
Base line
Limit of Contractor's Work area
WEST RETAINING WALL
Match exist.
Backfill excavation to exist. grades
Remove and reset boulders
Slope varies
FISH TRAP STRUCTURE
STONE & GRAVEL
GRAVEL SURFACE COURSE
6" Topsoil, Seeded
STA 2+50
BARRIER C.L. STA 0+00
Limit of Contractor's Work area
Guide rail
16' Wide single leaf gate
Slope varies
Limit of storage area
CONTRACTOR'S STORAGE AREA NO. 1
SEE SHEET 1 FOR LOCATION OF AREA NO. 2
100'
150'
GRAVEL SURFACE COURSE
Match exist. ground

(1)



PLAN

SCALE: 1" = 20'

2

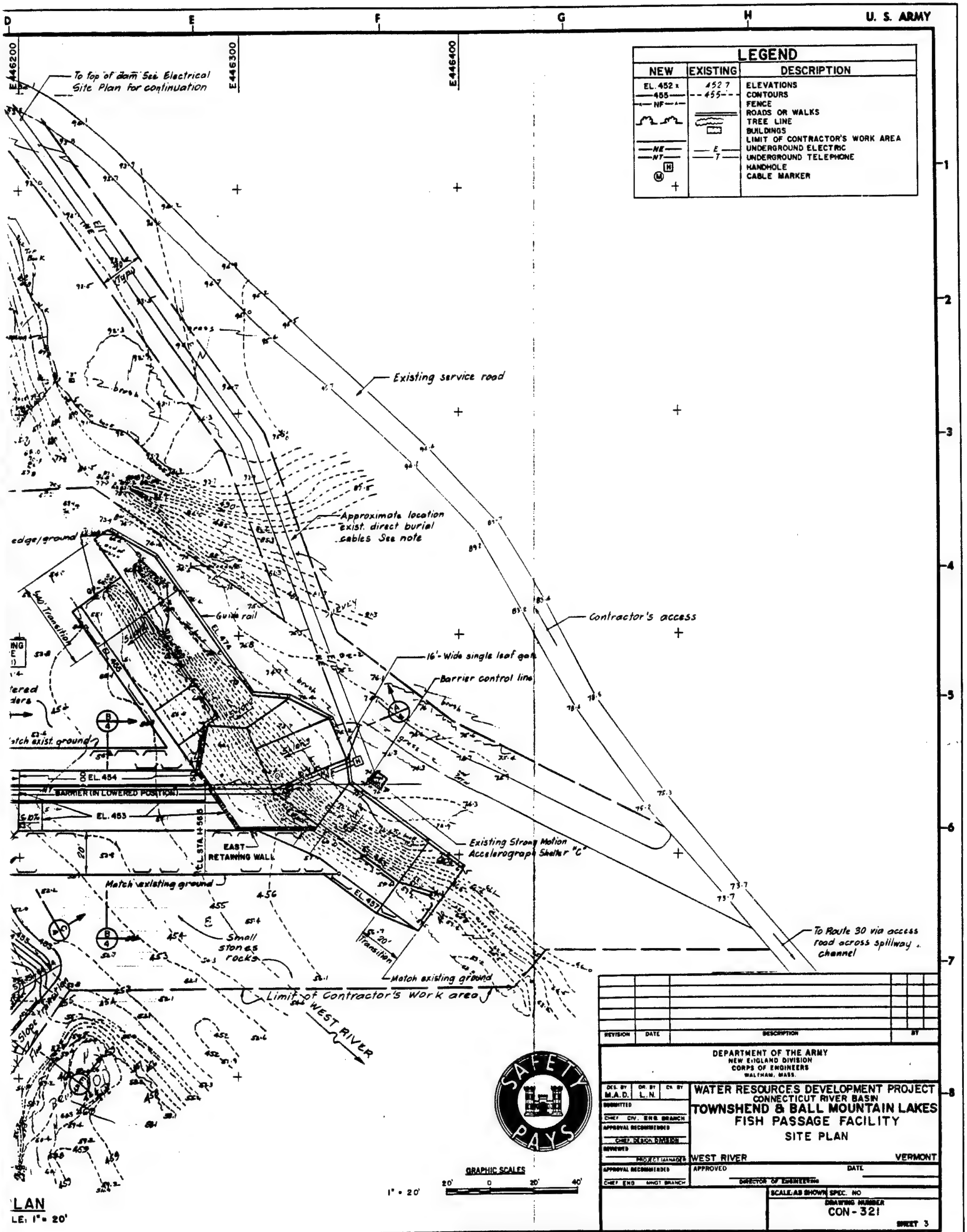
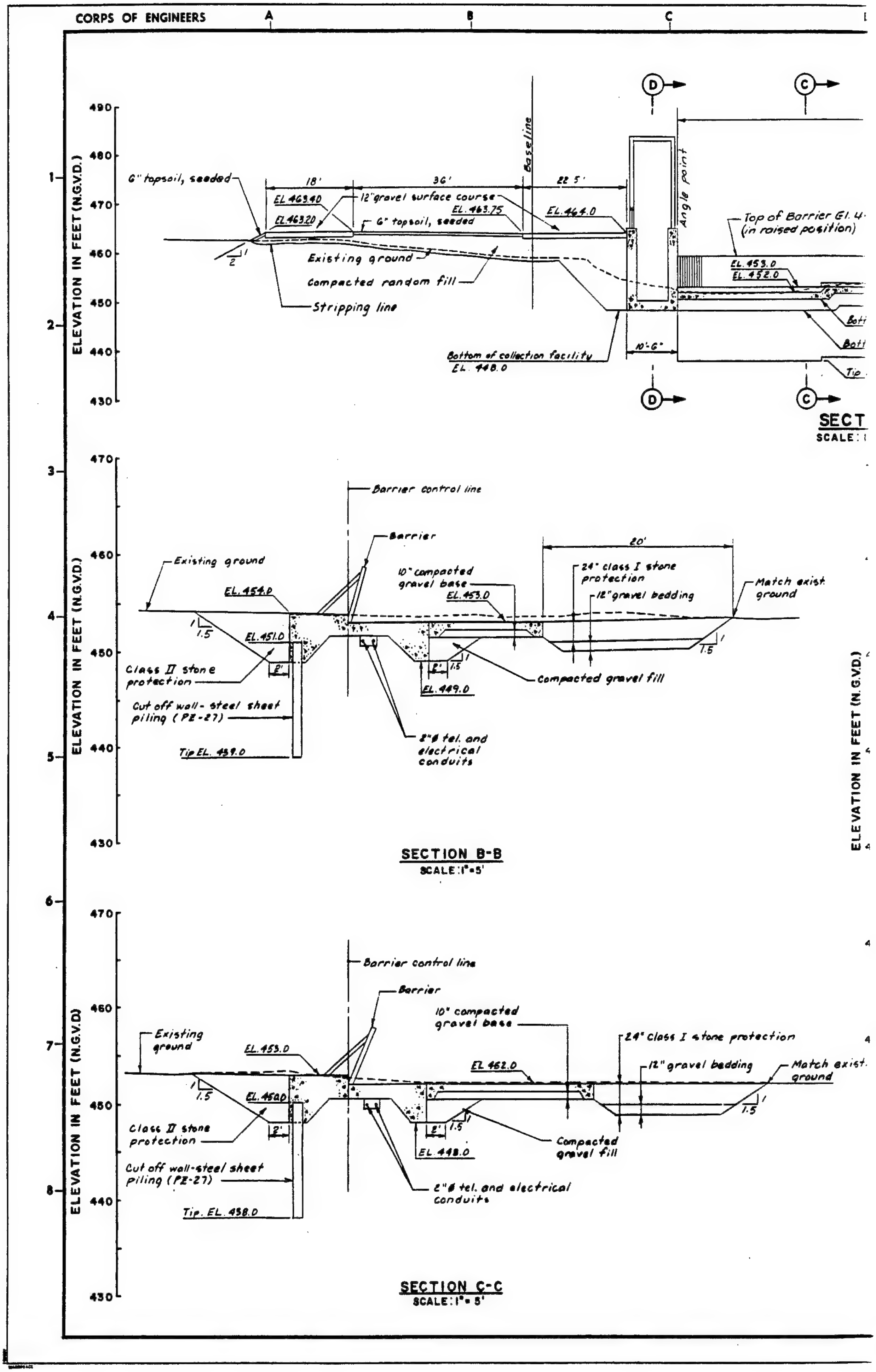
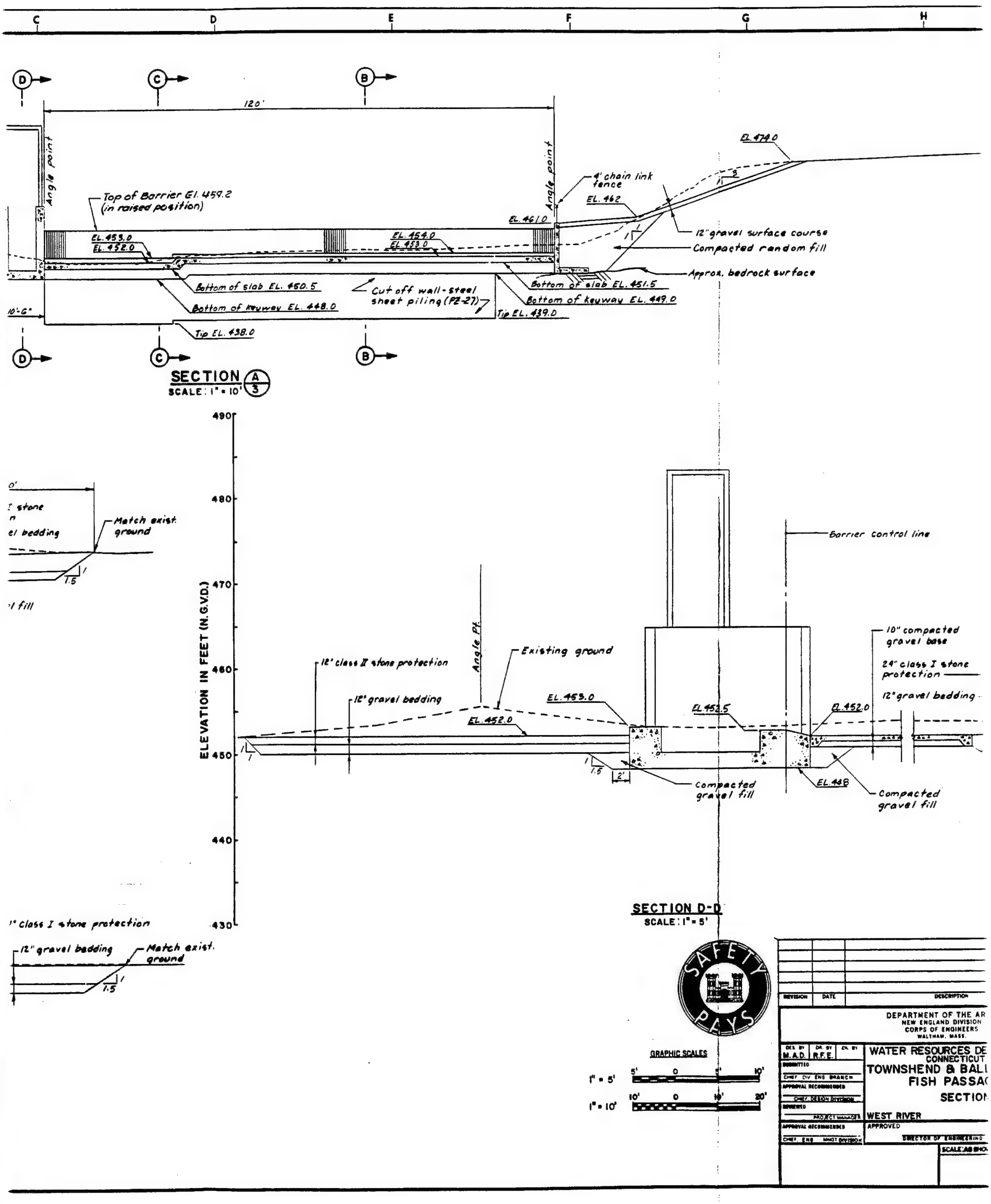

U. S. ARMY
D
E
F
G
H
E446200
E446300
E446400
LEGEND
NEW
EXISTING
DESCRIPTION
ELEVATIONS
CONTOURS
FENCE
ROADS OR WALKS
TREE LINE
BUILDINGS
LIMIT OF CONTRACTOR'S WORK AREA
UNDERGROUND ELECTRIC
UNDERGROUND TELEPHONE
HANDHOLE
CABLE MARKER
To top of dam See Electrical Site Plan for continuation
Existing service road
Approximate location exist. direct burial cables See note
Contractor's access
Guide rail
16'-Wide single leaf gate
Barrier control line
EL. 454
BARRIER (IN LOWERED POSITION)
EL. 453
EAST RETAINING WALL
Existing Strong Motion Accelerograph Shelter "C"
Match existing ground
Small stones rocks
EL 457
20' Transition
Match existing ground
Limit of Contractor's Work area
WEST RIVER
To Route 30 via access road across spillway channel
SAFETY PAYS
GRAPHIC SCALES
1" = 20'
REVISION
DATE
DESCRIPTION
BY
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.
M.A.D.
L.N.
WATER RESOURCES DEVELOPMENT PROJECT
CONNECTICUT RIVER BASIN
TOWNSHEND & BALL MOUNTAIN LAKES
FISH PASSAGE FACILITY
SITE PLAN
WEST RIVER
VERMONT
APPROVED
DATE
DIRECTOR OF ENGINEERING
SCALE: AS SHOWN
SPEC. NO
DRAWING NUMBER
CON-321
SHEET 3
LAN
LE: 1" = 20'

PLATE 8

(3)

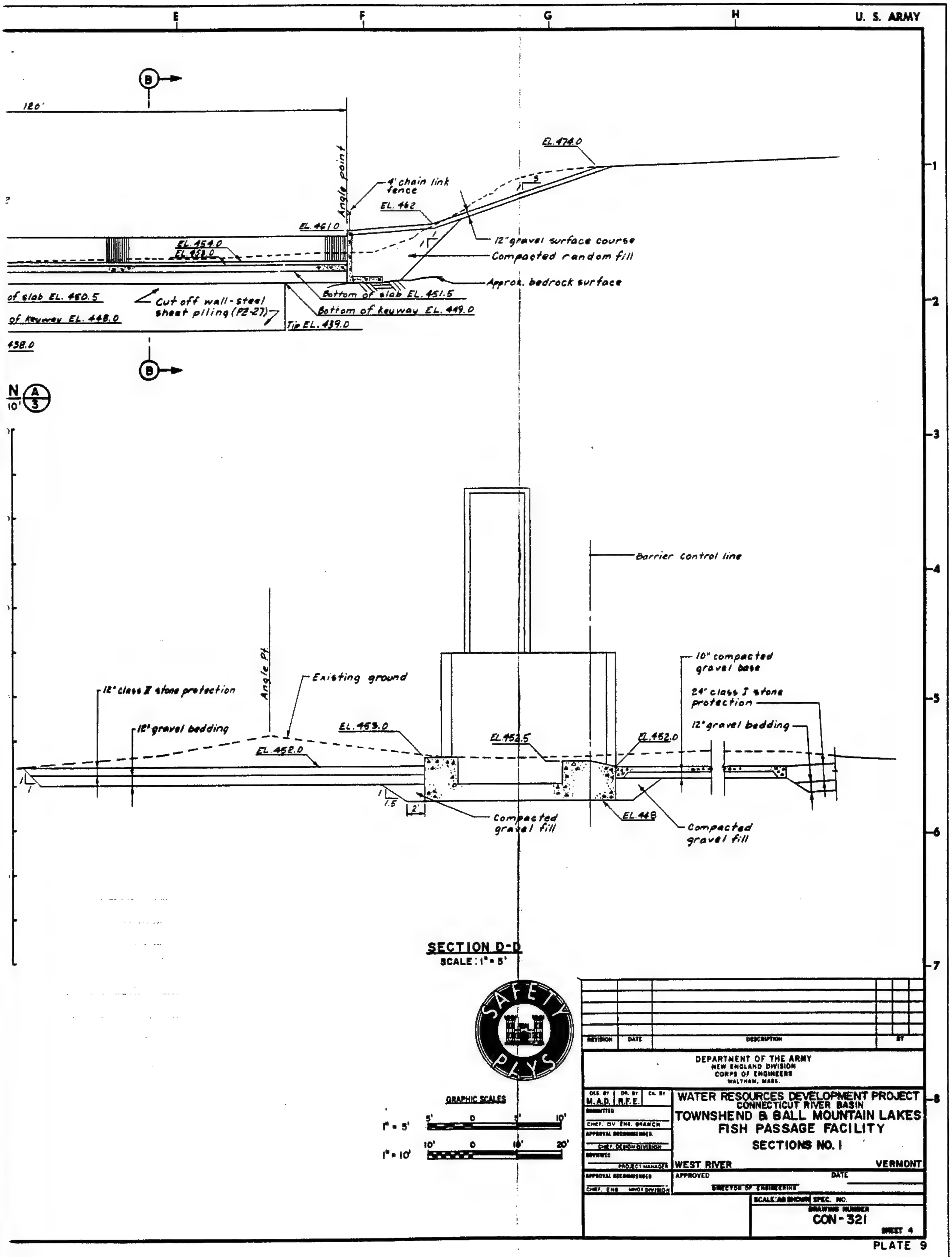

CORPS OF ENGINEERS
A
B
C
1
2
3
4
5
6
7
8
ELEVATION IN FEET (N.G.V.D.)
490
480
470
460
450
440
430
6" topsoil, seeded
18'
36'
22.5'
Baseline
Angle point
EL. 463.40
EL. 463.20
12" gravel surface course
EL. 463.75
EL. 464.0
6" topsoil, seeded
Top of Barrier El. 4
(in raised position)
EL. 453.0
EL. 452.0
Existing ground
Compacted random fill
Stripping line
Bottom of collection facility
EL. 448.0
10'-6"
D
C
SECT
SCALE:
Barrier control line
Barrier
20'
Existing ground
EL. 454.0
10" compacted gravel base
EL. 453.0
24" class I stone protection
12" gravel bedding
Match exist. ground
1.5
EL. 451.0
2'
Class II stone protection
EL. 449.0
Compacted gravel fill
Cut off wall-steel sheet piling (PZ-27)
Tip EL. 439.0
2"ø tel. and electrical conduits
SECTION B-B
SCALE: 1"=5'
Barrier control line
Barrier
10" compacted gravel base
Existing ground
EL. 453.0
EL. 452.0
24" class I stone protection
12" gravel bedding
Match exist. ground
EL. 450.0
Class II stone protection
EL. 448.0
Compacted gravel fill
Cut off wall-steel sheet piling (PZ-27)
Tip. EL. 438.0
2"ø tel. and electrical conduits
SECTION C-C
SCALE: 1"=5'

(1)



C D E F G H
120'
Angle point
Top of Barrier El. 459.2 (in raised position)
EL. 453.0
EL. 452.0
EL. 454.0
EL. 453.0
EL. 461.0
4' chain link fence
EL. 462
EL. 474.0
12" gravel surface course
Compacted random fill
Approx. bedrock surface
Bottom of slab EL. 450.5
Cut off wall - steel sheet piling (PZ-27)
Bottom of slab EL. 451.5
Bottom of keyway EL. 448.0
Bottom of keyway EL. 449.0
Tip EL. 439.0
Tip EL. 438.0
10'-6"
SECTION A/3
SCALE: 1" = 10'
ELEVATION IN FEET (N.G.V.D.)
490 480 470 460 450 440 430
Match exist. ground
stone
el bedding
l fill
12" class II stone protection
12" gravel bedding
Angle Pt.
Existing ground
EL. 453.0
EL. 452.0
EL. 452.5
EL. 452.0
EL. 448
Barrier control line
10" compacted gravel base
24" class I stone protection
12" gravel bedding
Compacted gravel fill
Compacted gravel fill
2'
SECTION D-D
SCALE: 1" = 5'
" Class I stone protection
12" gravel bedding
Match exist. ground
SAFETY PAYS
GRAPHIC SCALES
1" = 5'
1" = 10'
REVISION DATE DESCRIPTION
DEPARTMENT OF THE AR
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.
M.A.D. R.F.E.
WATER RESOURCES DE
CONNECTICUT
TOWNSHEND & BALL
FISH PASSAG
SECTION
WEST RIVER
APPROVED
DIRECTOR OF ENGINEERING
SCALE: AS SHO

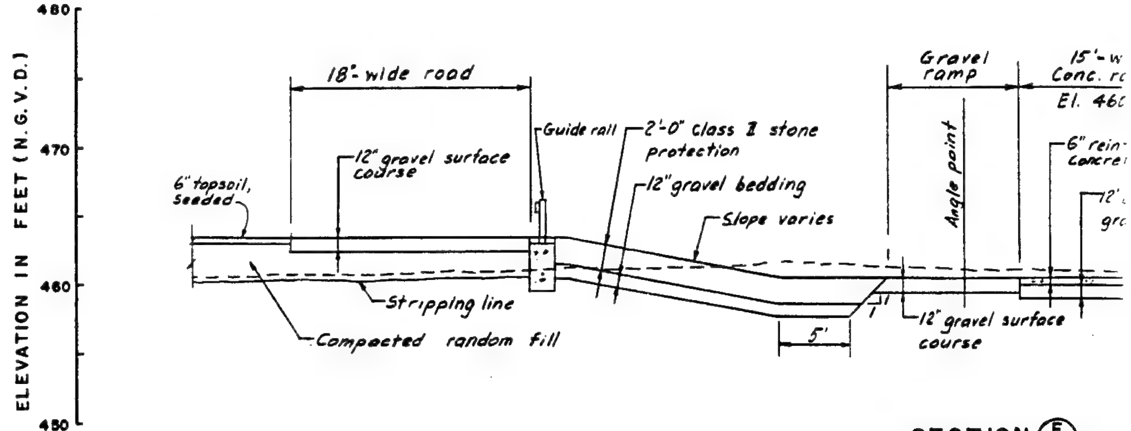
(2)



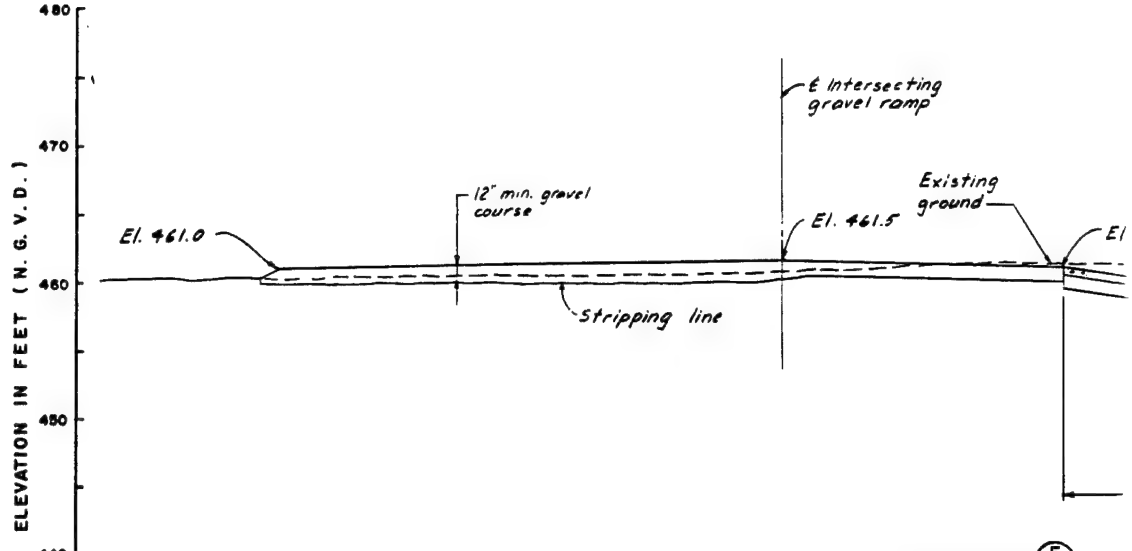
U. S. ARMY
E
F
G
H
120'
Angle point
4' chain link fence
EL. 474.0
EL. 462
EL. 461.0
EL. 454.0
EL. 453.0
12" gravel surface course
Compacted random fill
Approx. bedrock surface
of slab EL. 450.5
Cut off wall-steel sheet piling (PZ-27)
Bottom of slab EL. 451.5
Bottom of keyway EL. 449.0
of keyway EL. 448.0
Tip EL. 439.0
438.0
Barrier control line
Angle Pt.
12" class II stone protection
12" gravel bedding
Existing ground
EL. 453.0
EL. 452.0
EL. 452.5
EL. 452.0
10" compacted gravel base
24" class I stone protection
12" gravel bedding
Compacted gravel fill
EL. 448
Compacted gravel fill
SECTION D-D
SCALE: 1" = 5'
SAFETY PAYS
GRAPHIC SCALES
1" = 5'
1" = 10'
REVISION
DATE
DESCRIPTION
BY
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.
M.A.D.
R.F.E.
WATER RESOURCES DEVELOPMENT PROJECT
CONNECTICUT RIVER BASIN
TOWNSHEND & BALL MOUNTAIN LAKES
FISH PASSAGE FACILITY
SECTIONS NO. 1
WEST RIVER
VERMONT
APPROVED
DATE
SCALE: AS SHOWN
SPEC. NO.
DRAWING NUMBER
CON-321
SHEET 4
PLATE 9

(3)

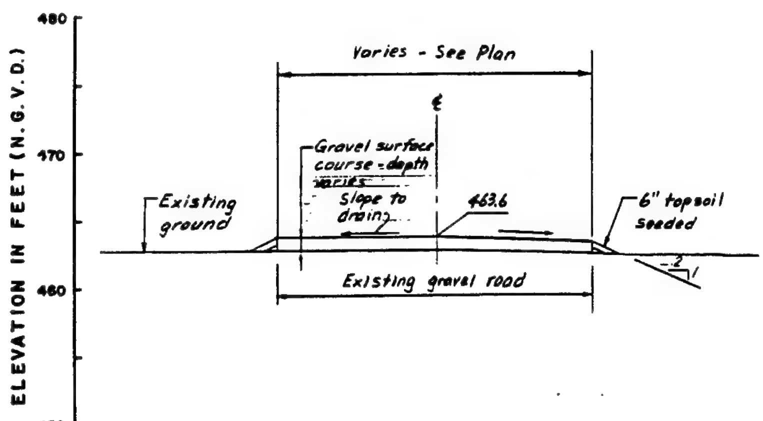
CORPS OF ENGINEERS



SECTION (E/3)
SCALE: 1" = 5'



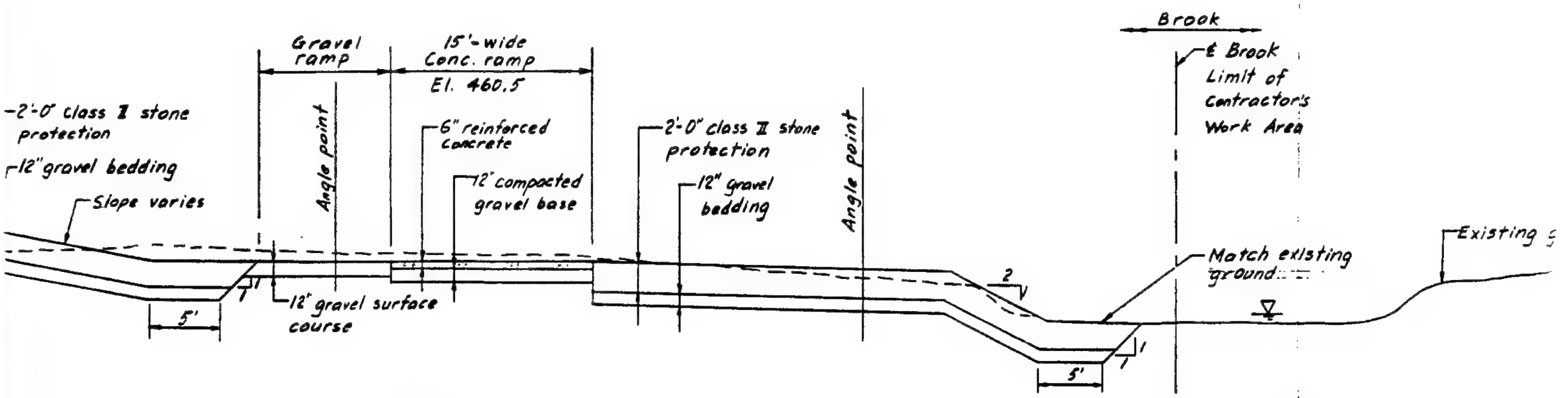
SECTION (F/3)
SCALE: 1" = 5'



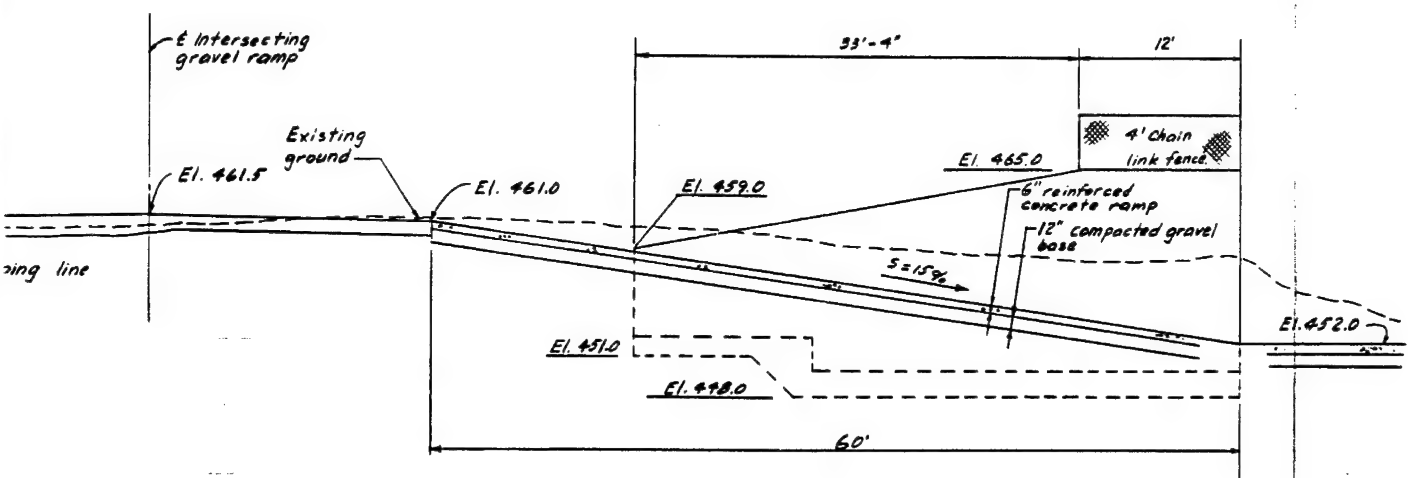
SECTION (G/3)
SCALE: 1" = 5'

(1)

C D E F G



SECTION (E/3)
SCALE: 1" = 5'



SECTION (F/3)
SCALE: 1" = 5'

6" topsoil
Seeded

SAFETY PAYS

GRAPHIC SCALES
1" = 5' 5' 0 5' 10'

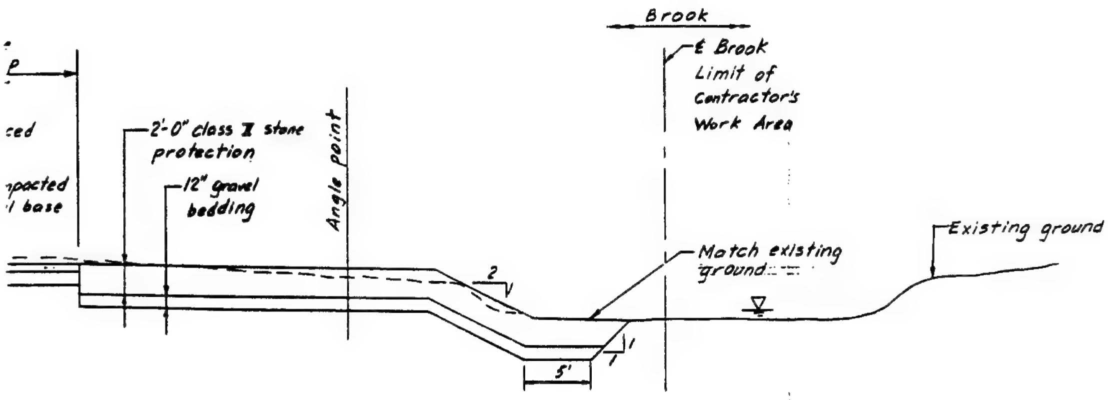
REVISION	DATE

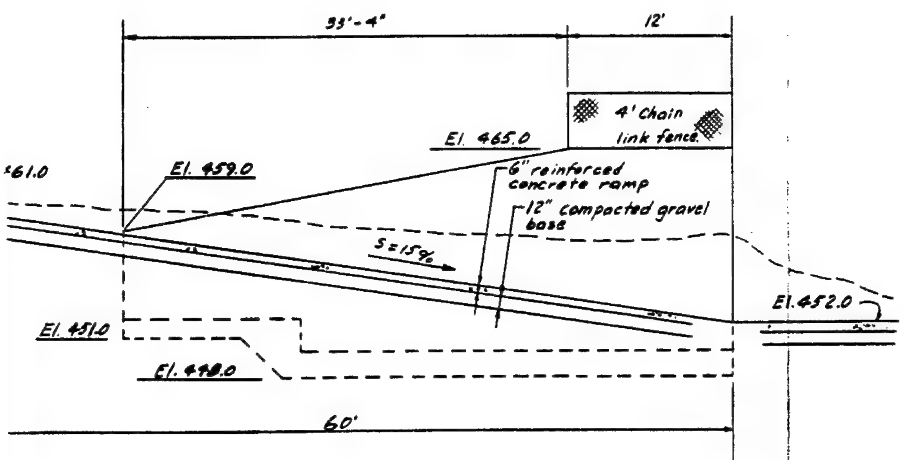
DES BY M.A.D. | DR. BY A.C. | CK. BY
SUBMITTED
CHIEF, CIV ENG BRANCH
APPROVAL RECOMMENDED
CHIEF, DESIGN DIVISION
REVIEWED
PROJECT MANAGER
APPROVAL RECOMMENDED
CHIEF, ENG MNGT DIVISION
WA
TO
WES
APP

(2)

U. S. ARMY

E F G H





GRAPHIC SCALES

1" = 5' 5' 0 5' 10'

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES BY M.A.D. DR. BY A.C. CK. BY

SUBMITTED

CHIEF, CIV. ENG BRANCH

APPROVAL RECOMMENDED

CHIEF, DESIGN DIVISION

REVIEWED

PROJECT MANAGER

APPROVAL RECOMMENDED

CHIEF, ENG. MNGT DIVISION

WATER RESOURCES DEVELOPMENT PROJECT
CONNECTICUT RIVER BASIN
TOWNSHEND & BALL MOUNTAIN LAKES
FISH PASSAGE FACILITY
SECTIONS NO. 2

WEST RIVER VERMONT

APPROVED DATE

DIRECTOR OF ENGINEERING

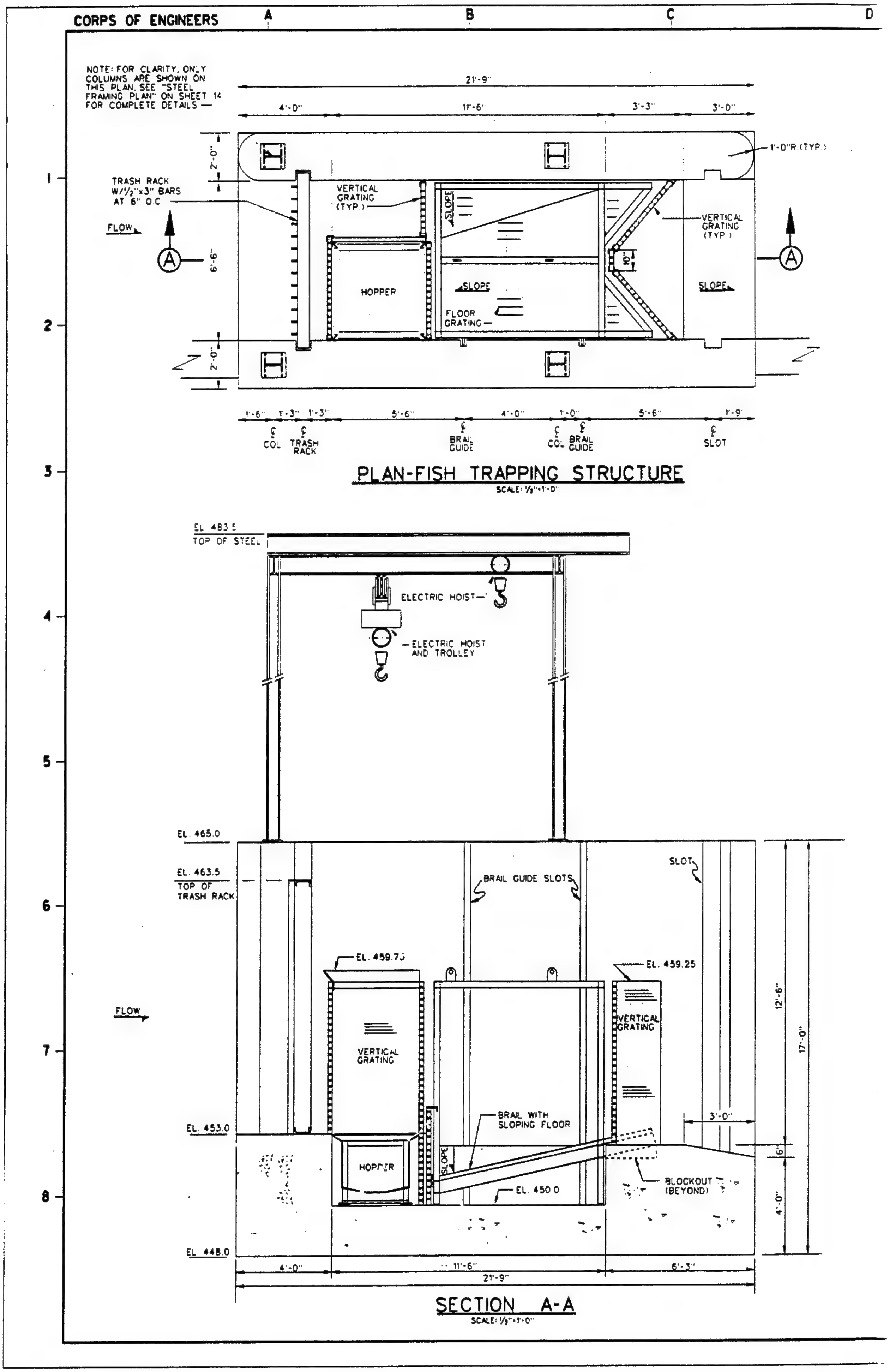
SCALE AS SHOWN SPEC. NO.

DRAWING NUMBER
CON-321

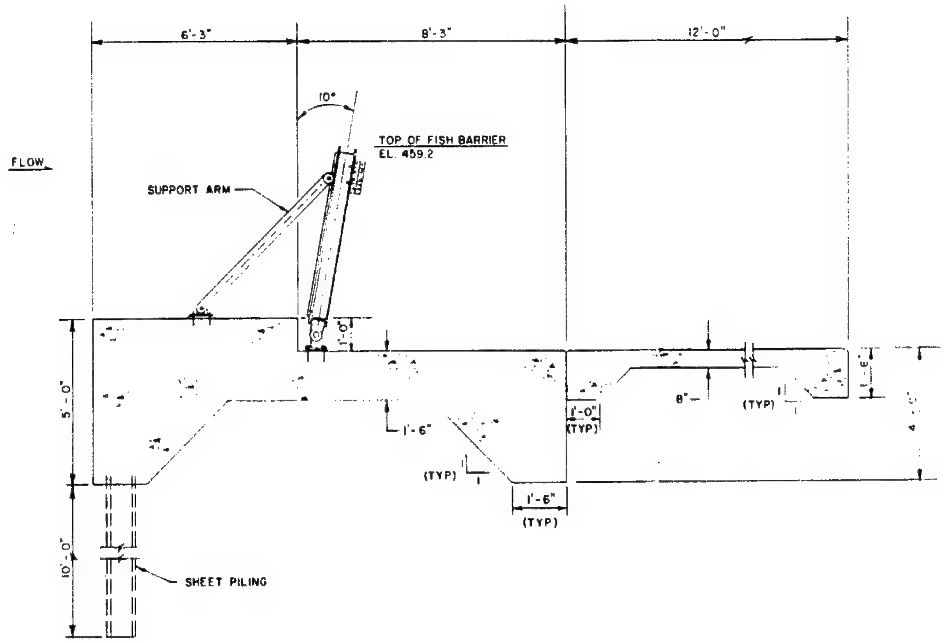
SHEET 5

PLATE 10

(3)


CORPS OF ENGINEERS
NOTE: FOR CLARITY, ONLY COLUMNS ARE SHOWN ON THIS PLAN. SEE "STEEL FRAMING PLAN" ON SHEET 14 FOR COMPLETE DETAILS
21'-9"
4'-0"
11'-6"
3'-3"
3'-0"
1'-0"R.(TYP.)
TRASH RACK W/1/2"x3" BARS AT 6" O.C.
VERTICAL GRATING (TYP.)
FLOW
HOPPER
SLOPE
FLOOR GRATING
PLAN-FISH TRAPPING STRUCTURE
SCALE: 1/2"=1'-0"
COL
TRASH RACK
BRAIL GUIDE
SLOT
EL. 483.5 TOP OF STEEL
ELECTRIC HOIST
ELECTRIC HOIST AND TROLLEY
EL. 465.0
EL. 463.5 TOP OF TRASH RACK
BRAIL GUIDE SLOTS
EL. 459.25
VERTICAL GRATING
BRAIL WITH SLOPING FLOOR
EL. 453.0
EL. 450.0
BLOCKOUT (BEYOND)
EL. 448.0
12'-6"
17'-0"
4'-0"
6'-3"
SECTION A-A
SCALE: 1/2"=1'-0"

D E F G H U.S.



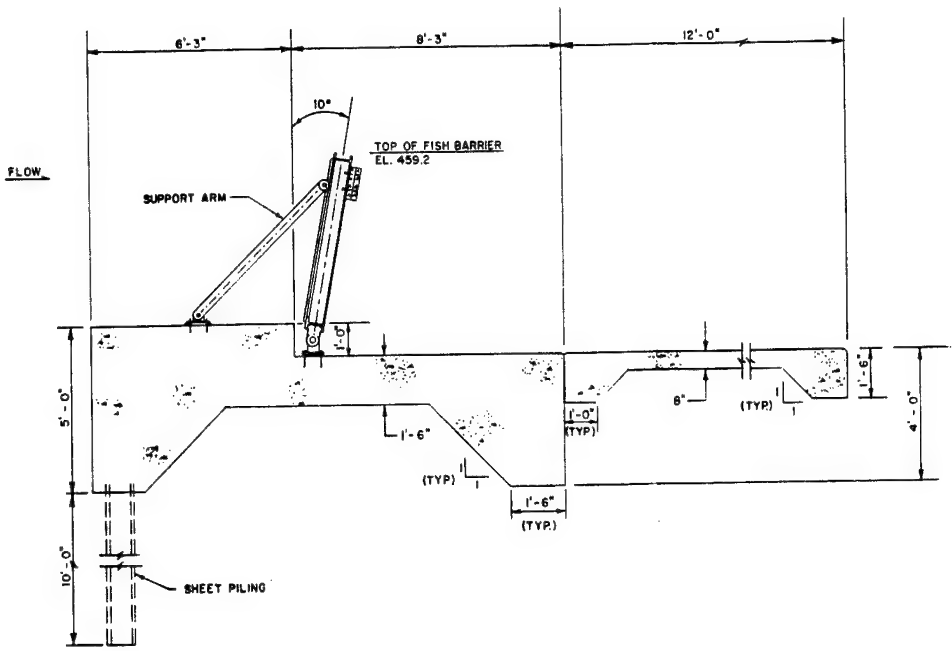
TYPICAL FISH BARRIER SECTION

SCALE 1/2" = 1'-0"

WATER RESOURCES DEVELOPMENT P
CONNECTICUT RIVER BASIN
TOWNSHEND & BALL MOUNTAIN
FISH PASSAGE FACILITY
FISH TRAPPING STRUCTURE & BARRIEF
WEST RIVER

CON-321

(2)



TYPICAL FISH BARRIER SECTION

SCALE: 1/2" = 1'-0"

WATER RESOURCES DEVELOPMENT PROJECT
CONNECTICUT RIVER BASIN
TOWNSHEND & BALL MOUNTAIN LAKES
FISH PASSAGE FACILITY
FISH TRAPPING STRUCTURE & BARRIER DETAIL
WEST RIVER VERMONT

JAN 1992

DRAWING NUMBER
CON-321

PLATE 11

(3)

Data from the USFWS report, included as Appendix D, suggests that little smolt mortality probably occurs during passage through Ball Mountain dam. About 90 percent of the fish passing through the dam continued on well downstream, and were presumed to be alive (because dead control smolts drifted less than 0.3 miles). Some of the remaining fish that passed through Ball Mountain Lake failed to reach Townshend Lake. Loss of these fish cannot be attributed to passage through Ball Mountain Lake, however, since the percentage of fish passing through Ball Mountain Lake which failed to reach Townshend Lake is similar to the percentage of Cobb Brook control fish that failed to reach Townshend Lake. Smolts that passed through Ball Mountain Lake and reached Townshend Lake appear viable, because they were able to negotiate the lake as quickly, or more quickly, than control fish released below Ball Mountain Lake (at Cobb Brook).

As a result of this additional study, it is concluded that a 25-foot pool allows the downstream passage of smolts with a minimum of delay and mortality.

The total estimated construction cost of the revised recommended plan is $790,000 as shown in the tabulation below:

Item	Cost
Fish Trap Facility (including outlet modifications at Townshend Lake)	$680,000
Automated Gate at Ball Mountain Lake	40,000
Construction Supervision and Administration	70,000
Total Cost	$790,000

The Federal cost to operate and maintain these facilities is estimated at $50,000 annually. Major operation items include checking the facility daily during the migration season; transporting captured fish; setting up and dismantling the barrier racks; and removing accumulated debris.

IMPACTS OF THE RECOMMENDED PLAN

This section summarizes the potential impacts associated with implementing the recommended Atlantic salmon restoration program at Townshend and Ball Mountain Lakes.

Aquatic Habitat. Construction of the proposed trap facility would require dredging a portion of river bottom to facilitate construction of the fish ladder and barrier. Overall, several thousand cubic yards of rock and gravel would be removed from the river and disposed of at an upland location. Several thousand square feet of natural river bottom would be replaced by the barrier and trap.

Some additional aquatic habitat would also be disturbed by cofferdam construction.

Using Townshend and Ball Mountain Lakes to help regulate West River flows during construction may result in somewhat more variable flow than normal. This would have a minor short term adverse impact on habitat quality. The normal 65 foot summer pool at Ball Mountain Lake would not be maintained, and the pool levels at both Townshend and Ball Mountain Lakes will be subject to more extreme fluctuations.

Regulation of reservoir releases from Ball Mountain Lake to facilitate smolt passage would result in temporary loss of some aquatic habitat provided by the summer reservoir pool. Under this plan, establishment of the pool would be delayed from early spring until June. In most years the pool would be restored quickly, but in exceedingly dry years, sufficient inflow may not be available to restore the pool until later in the summer. The potential temporary loss of this habitat is undesirable, but is not considered significant.

Water Quality. In-stream work during construction of the capture facility would temporarily increase suspended sediment levels in the West River for a short distance downstream of the project area. Impacts should be minimal because material dredged from the river would be primarily rock and coarse sediments with low fines content. Also, cofferdams will be used and instream work would occur during low flow periods to the maximum practical extent. Operation of the capture facility would have no long-term adverse impact on water quality in the river.

Maintaining a 25-foot pool at Ball Mountain Lake during the smolt outmigration period, could slightly increase turbidity downstream of the dam during storm events. However, monitoring during a 1990 storm event found that maintenance of a 25-foot pool resulted in no measurable impact on turbidity downstream of the dam.

Lowering the Ball Mountain pool to 25-foot during late April and May should have no impact on West River water temperature downstream of the dam. Restoration of the 65-foot pool during summer will insure that cool outflow from the reservoir will continue to moderate tailrace water temperature.

Biological Resources. The proposed capture facility should be highly effective in trapping adult Atlantic salmon. Virtually all salmon that reach Townshend Lake will be trapped and successfully transported upstream and mortality rates due to handling are expected to be negligible.

Adult Atlantic salmon may be present in the pool immediately downstream of Townshend dam during construction of the capture facility. If significant numbers of salmon are present in the pool, they will be captured by nets or electroshocking and released upstream of Townshend Lake.

Maintaining a 25-foot pool at Ball Mountain Lake during the smolt oumigration period will insure that smolts pass through the dam with minimal delay or mortality. This conclusion is supported by USFWS smolt studies conducted in 1990 and 1991 (see Appendixes C and D). Both studies

found that smolts quickly pass through Ball Mountain Lake with a 25-foot pool. Average delays were 2 to 6 hours, but delays of this order are not considered significant. The 1991 studies found that smolts passing through the dam with a 25-foot pool probably suffer little or no mortality. Studies both years also found that the permanent pool at Townshend Lake does not significantly delay smolt outmigration.

The proposed timeframe for maintaining a 25-foot pool at Ball Mountain Lake (late April through May) should normally encompass most of the peak smolt outmigration period. Some smolts may migrate earlier in April, particularly during unusually warm years. Passage of these fish will probably be delayed until the reservoir is drawn down during the late April in conjunction with whitewater releases. Although this delay is not considered significant, it is likely that fish passing through the reservoir during the white water releases will suffer a greater risk of mortality due to pressure effects and abrasion. If future studies find that a significant percentage of smolts migrate downstream prior to the late April whitewater releases, further adjustment in reservoir operation will be considered.

Some smolts may be injured during passage through the fish barrier at the Townshend Lake capture facility. Projected approach velocities greater than 3 feet per second at the barrier could cause impingement of smolts passing downstream while the barrier is in place. Because the barrier will not be in place until well after peak smolt outmigration, barrier impacts on smolts should be minimal.

During construction of the trap facility, fish and other aquatic life near the work area will be displaced. Some mortality of fish eggs, fry, and invertebrates may occur, but following completion of the work, disturbed areas will be recolonized. Downstream impacts should be minimal due to the coarse nature of bottom sediments.

Changing flows in the West River during construction may impact fish eggs, fry and invertebrates downstream of Ball Mountain and Townshend Lakes. The impacts will be mimimized by providing a minimum flow of 90 cfs (or inflow if less) below both lakes. In addition, any reductions in flows below 200 cfs will be done gradually to minimize stranding of aquatic life downstream of the dams.

Fluctuations in Townshend Lake levels could adversely impact eggs and fry of bass and other fish. Maintaining a 25-foot summer pool at Ball Mountain Lake during construction will result in loss of normally cool outflow from the reservoir, and could have a minor adverse impact on the brown trout fishery in the West river immediately downstream of the dam.

Operation of the trap facility should have no significant impact on the existing fish community at the site. The trap will occasionally catch resident species such as brown trout. These fish will be released from the trap and will not be transported upstream with the salmon. The fish barrier should have no significant impact on movements of fish occurring in the river. Some impingement of smaller fish may occur while the barrier is in place when flows exceed 2-3 feet per second.

There is some evidence that reintroduction of salmon in rivers and streams may lead to the decline of other salmonid populations due to competition. In the West River, populations of brook trout and brown trout could be effected by Atlantic salmon restoration efforts. Impacts to trout resulting from salmon reintroduction will occur with or without the proposed Corps project as a result of continued fry stocking.

In addition to Atlantic salmon, the Townshend Lake facility will probably capture some adult sea lamprey. Unless lamprey are selectively removed from the trap prior to upstream transport, operation of the facility will result in reintroduction of these fish upstream of Townshend Lake. Sea lamprey are native to the West River basin, but are currently not present upstream of Townshend Lake.

Changes in regulation of Ball Mountain Lake to enhance smolt passage will have little adverse impact on existing aquatic life in the reservoir. Under current operating conditions the existing fishery and invertebrate community is already disturbed each year when the 65-foot pool is dropped to 25-foot during the late fall, winter, and early spring. The proposed delay in reestablishing the pool until June 1, rather than in April, should have little additional adverse impact on aquatic life. The State of Vermont will continue to stock Ball Mountain Lake, but will delay stocking until after restoration of the 65-foot pool.

Any slight increases in silt transport from Ball Mountain Lake caused by the proposed reservoir regulation plan would have no significant impact on brown trout or other species which spawn in the West River downstream of the dam.

<u>Vegetation.</u> A small amount of riparian vegetation (<0.1 acre) would be lost due to construction of the trap facility. Impacts to riparian areas have been minimized to the greatest practical extent.

Use of Ball Mountain and Townshend Lakes to regulate West River flow during project construction could have an adverse impact on trees and shrubs growing within both reservoirs. Of most concern is the potential impact to trees, particularly if inundation occurs during the growing season. Inundation has resulted in substantial defoliation and tree mortality. The most sensitive species were white pine, aspen, red spruce, hemlock, and birch.

Impacts of inundation on trees during construction of the trap facility are difficult to predict. If construction occurs during a relatively wet year, and trees are frequently flooded during the growing season, or flooded for an extensive period due to a major event, substantial defoliation and mortality might occur. If construction occurs during a relatively dry year, no mortality would occur. All practicable measures will be taken to minimize flooding of forested areas above the 80-foot stage at Ball Mountain Lake and the 30 to 35 -foot stage at Townshend Lake.

Short-term inundation could also result in some defoliation and/or mortality of emergent and aquatic vegetation at Townshend Lake. Impacts are difficult to predict since little is known about flooding tolerance of emergent or aquatic species. Once again the severity of impacts would depend on the frequency and magnitude of storage events during the growing season. Both emergents and aquatic vegetation should be tolerant of prolonged inundation prior to and after the growing season.

Changes in regulation at Ball Mountain Lake for smolt passage should have no significant impact on riparian vegetation occurring along the periphery of the reservoir.

Wildlife. Wildlife occurring near the proposed capture facility and in areas inundated as a result of the water control plan will temporarily be displaced during construction. Displaced animals would probably be subjected to somewhat higher mortality due to stress caused by loss of optimal habitat, and by predation. No nesting mortality should occur among birds since fledging will have occurred prior to construction. Cavity nesting birds such as chickadees and woodpeckers may benefit in the long-term due to increased snag availability if any trees are killed by flooding.

Lowering Ball Mountain Lake to facilitate downstream smolt passage could have a minor impact on merganser nest site selection. Although no inventory of nest sites at the reservoir is available, mergansers generally prefer tree cavities close to water. Since nest site selection occurs during late April and early May, some nest sites selected with a 65-foot pool may be rejected because they would be too far from the open water of a 25 foot pool.

Atlantic salmon restoration efforts in the West River basin have prompted some conflicts with ongoing efforts to restore osprey in the area. Fisheries managers have expressed concerns that osprey may prey upon a significant number of salmon smolts. Given the large population of smolts in the basin, and heavy existing predation by mergansers, added predation pressure by several pairs of osprey would not be significant.

Threatened and Endangered Species. Operation of the Townshend Lake capture facility should have no significant impact on any species considered threatened or endangered by the U.S. Fish and Wildlife Service or the State of Vermont.

Construction of the capture facility has the potential to impact a population of the brook floater, a rare freshwater mussel (and potential Federally listed threatened or endangered species) found near Scott's Covered Bridge. This site is about 2,000 feet downstream of Townshend Lake. Of principal concern is the possibility that rapid reductions in outflow from the dam will dewater mussel habitat, and result in mortality of stranded mussels.

A minimum flow of 90 cubic feet per second at Townshend Lake (or inflow if less) will be maintained during project construction to minimize mussel stranding. A rate of 90 cfs will insure that most available mussel habitat downstream of the bridge remains submerged. In addition, any reductions in flow to rates below 200 cfs will be done gradually to minimize stranding of aquatic life.

Changes in operation of Ball Mountain Lake to enhance smolt outmigration should have no impact on any species considered threatened or endangered by the U.S. Fish and Wildlife Service or the State of Vermont.

Historic and Archaeological Resources. The proposed site for the capture facility was extensively disturbed by construction of Townshend Dam. A 1986 Cultural Resource Management Study, determined that the area around the dam and outlet structures had no archaeological potential. It is anticipated that construction of the capture facility should have no effect upon any structure or site of historic, architectural or archaeological significance as defined by the National Historic Preservation Act of 1966, as amended. The Vermont State Historic Preservation Officer (VT SHPO) has concurred with this determination.

A 1982 Cultural Resources Management Study at Ball Mountain Lake identified terraces that could be affected by pool fluctuations. Since construction of the trap facility will require increased regulation at Ball Mountain Lake, these terraces were investigated further.

The major potential impact concerned erosion, but with the implementation of an erosion monitoring plan, the proposed project should have no effect upon any structure or site of historic, architectural or archaeological significance as defined by the National Historic Preservation Act of 1966, as amended. The Vermont State Historic Preservation Officer has concurred with this determination.

Social and Economic Resources. Implementation of the water control plan may result in periodic flooding of the Townshend Lake recreation area. If flooding occurs frequently, the facility may be closed for the season. The normal fall releases from Ball Mountain Lake for white water recreation may be precluded due to construction in 1992.

After the capture facility becomes operational, the state of Vermont will probably prohibit fishing within about 200 to 300 feet of the facility from mid May through November. This reach of the river is on Federal land, and is presently a popular fishing spot.

Restoration of adult salmon in the upper West River basin could create an opportunity for a late fall or spring kelt fishery (kelts are adult salmon following spawning). The State of Vermont would probably sanction this fishery, since the likelihood of kelts migrating successfully downstream through mainstem Connecticut River dams and returning to the West River to spawn in subsequent years is very low. Eventually, a much more valuable fishery for "bright salmon" (2-3 year old adult salmon returning to spawn) might also be established.

The capture facility will attract additional visitors to the area, and provide an excellent opportunity for the Corps to educate the public about Atlantic salmon and the Connecticut River salmon restoration program.

Proposed changes in regulation of Ball Mountain Lake to enhance smolt passage will result in the loss of one of the two spring weekends traditionally dedicated for whitewater recreation. At present, it appears that releases for general whitewater recreation will be made on the remaining weekend, and that National Whitewater Canoe Championships will no longer be held on the West River.

Delayed establishment of the 65-foot pool at Ball Mountain Lake until June will have a minor aesthetic impact due to prolonged exposure of extensive, unsightly, mudflats.

SECTION IV

FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

FINDINGS AND CONCLUSIONS

As a result of evaluation of alternative fish passage measures and coordination with Federal and State fish and wildlife agencies, it has been concluded that facilities necessary to allow the upstream passage of adult Atlantic salmon and downstream passage of smolts (juvenile salmon) are technically feasible and desirable at Townshend and Ball Mountain Lakes. No additional lands, easements, rights-of-way or relocations are necessary as the proposed facilities will be constructed entirely on Federal lands. The plan selected for implementation includes:

- o construction of a fish barrier and instream trap, downstream of Townshend dam for upstream passage (see Plates 8-11);
- o modifying the operation of Ball Mountain Lake to provide a 25-foot pool from the end of the last weekend in April to June 1; Lowering the pool to 25-feet will be accomplished in conjunction with providing controlled whitewater releases during the last weekend in April.
- o automating one of the gates to assist in maintaining the 25-foot pool at Ball Mountain Lake; and
- o modifying the outlet structure at Townshend Lake by notching the weir and providing a splash pool at the foot of the outlet weir.

As the next step in providing these Congressionally authorized improvements, the preparation of Plans and Specifications is continuing. Coordination with the State of Vermont to obtain a Local Cooperation Agreement is also underway. The total estimated costs for project development and construction are shown below:

	Cost
Preparation of Specific Project Report	190,000
Engineering and Design	305,000
Construction (incl.Supervision & Administration)	790,000
Total Costs	$1,285,000

RECOMMENDATIONS

I recommend that the facilities proposed in this report and evaluated in the attached Environmental Assessment, with a total estimated cost of $1,285,000, be approved.

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress.

13 Feb 92
DATE

Philip R. Harris
PHILIP R. HARRIS
Colonel, Corps of Engineers
Commanding

ENVIRONMENTAL ASSESSMENT

ENVIRONMENTAL ASSESSMENT

CONNECTICUT RIVER BASIN

FISH PASSAGE INVESTIGATION

TOWNSHEND AND BALL MOUNTAIN LAKES

WEST RIVER, VERMONT

Prepared by:

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January 1992

New England Division
U.S. Army Corps of Engineers
Waltham, Massachusetts

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I. INTRODUCTION

A. Study Purpose and Need

Actions proposed in this study are intended to enhance ongoing state and Federal efforts to restore Atlantic salmon (Salmo salar) in the West River, Vermont. Under present conditions salmon are prevented from reaching most potential spawning habitat in the West River basin by the Corps' Townshend and Ball Mountain Lake flood control dams. A conservation pool maintained at Ball Mountain Lake also impairs downstream migration of juvenile salmon (smolts)[1].

B. Study Authority

This project is authorized by Section 872 of the 1986 Water Resources Development Act. Study funds were provided by the FY 1990 Energy and Water Development Act.

II. PROJECT DESCRIPTION

A. Selected Plan

1. Upstream Passage

Upstream passage of adult Atlantic salmon will be accomplished by construction of a capture facility downstream of Townshend Lake dam (see Plates 8 thru 11 in the Specific Project Report). The facility will consist of a fish barrier built across the river and an in-stream trap. Salmon captured in the trap will be transferred to a holding tank and trucked upstream of Ball Mountain Lake and/or Townshend Lake. The barrier and trap will be operated between mid May and November. Operation in any given year will commence once salmon have passed the Vernon Dam on the Connecticut River (Vernon Dam is the last obstruction to migrating salmon downstream of Townshend Lake). It is projected that eventually at least 550 salmon will be trapped at the facility each year (see U.S. FWS, 1982). Operation of the facility and upstream placement of captured salmon will be closely coordinated with the Vermont Department of Fish and Wildlife.

Construction of the facility is currently scheduled to occur from June, 1992 through February, 1993. In-stream work should be completed by the end of November, 1992.

Note 1: Although no natural Atlantic salmon reproduction currently occurs in the West River basin, large numbers of fry are stocked in the basin each year upstream of Townshend Lake. Fry survival is good, and large numbers of smolts produced above Townshend Lake are thought to migrate seaward each year.

Construction of the facility will require placement of concrete, sheet piling, stone protection, and ordinary fill (for cofferdams) in the river. Site preparation work will require excavation of several thousand cubic yards of coarse grained material and rock from the river. The material will be disposed of at an upland disposal site.

Water control during construction will be accomplished by using cofferdams and by regulating releases from Ball Mountain and Townshend Lakes (see Appendix F of the Specific Project Report). Maximum controlled releases from Townshend Lake will be 1000 cfs during working hours and 1,500 cfs during non-working hours. Maximum controlled releases from Ball Mountain Lake will be 700 cfs during working hours and 1,000 cfs during non-working hours. These maximum release rates will be permitted until pool stages at Townshend and Ball Mountain Lakes reach 47-foot and 115-foot, respectively. Once these pool stages are reached, normal flood control procedures will be implemented, and releases greater than 1,000 cfs may be required. Minimum flows of 90 cfs, or inflow to the reservoirs if less, will be maintained at both projects at all times during construction. In order to protect aquatic life downstream of the dams, reductions in flow below 200 cfs will be made gradually over a 12-24 hour period.

2. <u>Downstream Passage</u>

A 65-foot conservation pool is normally maintained at Ball Mountain Lake during the smolt outmigration period (late April through May). In order to pass through the dam, smolts must sound to the bottom of the pool and pass through the outlet works. Under these conditions most smolts are probably either unable to find the outlet or are significantly delayed. Smolts that do pass through the dam are likely to be injured or killed by extreme pressure changes during passage through the outlet gates.

To enhance downstream smolt passage through Ball Mountain Lake the pool will be lowered to the 25-foot stage from immediately after the last weekend in April until June 1. Up until the last weekend in April, the pool will be maintained at normal spring levels (ca. 65-foot stage) to allow for controlled whitewater recreation releases. After June 1, the normal 65-foot summer pool will be restored. A minimum flow of 90 cfs, or inflow to Ball Mountain Lake if less, will be maintained while restoring the 65-foot pool. The center gate at the dam outlet works will be automated to ease regulation of a 25-foot pool during the smolt outmigration period. This protocol was developed during a 14 November, 1990 meeting between the Corps of Engineers, U.S. FWS, Vermont Department of Fish and Wildlife, and the Appalachian Mountain Club.

U.S. Fish and Wildlife Service studies using radio tagged smolts indicate that wild and hatchery reared smolts pass through the 25-foot Ball Mountain Lake pool with minimal delay (see Appendix C and D of the Specific Project Report). Data provided by the 1991 study also suggests that little smolt mortality probably occurs during passage through Ball Mountain dam (see Appendix D). About 90 percent of smolts passing through the dam continued on well downstream, and were presumed to be alive (dead "controls" moved < 0.3 mile). Some of the smolts that passed through Ball Mountain Lake

failed to reach Townshend Lake. Loss of these fish does not appear due to passage through Ball Mountain Lake, since the percentage of fish which failed to reach Townshend Lake was similar to the percentage of live "control" fish that failed to reach the lake. Smolts that passed through Ball Mountain Lake and reached Townshend Lake appear viable, and negotiated the lake as quickly, or more quickly, than "control" fish released below Ball Mountain Lake.

The recommended plan assumes that most smolt outmigration from the river occurs after late April. If future studies find that a substantial proportion of smolts migrate before late April it may be necessary to lower the reservoir to the 25-foot stage earlier than is currently proposed. Lowering the reservoir earlier in April would be feasible from a flood control standpoint, but could preclude making controlled spring releases for whitewater recreation.

Under current conditions, outmigrating smolts pass over a 21 foot outlet weir at Townshend Lake. Although the lake poses little or no delay to the smolts, there is concern that smolts may be injured while passing over the weir. In order to minimize risk of injury, stop logs will be installed at the base of the weir to provide a splash pool. The outlet weir will also be notched to concentrate flow and provide greater attraction velocity.

B. <u>Alternatives</u>

1. <u>Upstream Passage</u>

The selected alternative is a refinement of an earlier plan which called for an in-stream barrier, coupled with a short fishway and holding/brailing pool (see Plate 4 and 5 in the Specific Project Report). This plan had the support of resource agencies, and was the selected alternative until concerns about its cost and performance at low flows arose during formulation of detailed engineering plans. The final selected plan is considered to be a significant improvement over the earlier plan because it eliminates the need for a fishway and associated pumps, is less costly to construct and operate, and will perform more reliably under low flow conditions.

Two other plans for a Townshend Lake capture facility were considered (see Plates 6 and 7 in the Specific Project Report). These plans called for a short fish ladder and trap near the Townshend Lake outlet, and a barrier across the outlet conduit. These designs were somewhat less costly than the proposed plan, and had lesser impacts to aquatic habitat. They were rejected, however, because salmon might not easily find the fishway entrance due to swirling waters near the dam outlet. There was also concern that a barrier placed across the outlet conduit could impede reservoir operations during a flood event.

Construction of fish ladders or elevators at Townshend and Ball Mountain Lakes was also considered. These facilities would enable salmon to bypass the dams, but would be much more costly and difficult to construct than a capture facility at Townshend Lake. The proposed plan will also provide an opportunity for effective passage at two non-Corps dams on the West River upstream of Ball Mountain Lake.

2. Downstream Passage

Operating Ball Mountain Lake under run of the river conditions with no pool was considered. This option was rejected primarily because it would result in the erosion and downstream transport of a large amount of sediment that has accumulated within the reservoir. Lowering the pool to run of the river levels is considered unnecessary to facilitate smolt outmigration because the U.S. Fish and Wildlife Service smolt release studies suggest that smolts passing through the 25-foot pool suffer no substantial delay, mortality, or injury. The decision to operate the lake with a 25-foot pool will be reevaluated if new information suggests that a 25-foot pool has a significant adverse impact on smolt outmigration.

The possibility of maintaining year-round run of the river conditions at Ball Mountain Lake, with no 65-foot conservation pool, was suggested by the Vermont Department of Environmental Conservation and the Vermont Department of Fish and Wildlife (see 23 July 1991 letter from Mr. Jeff Cueto and 22 August, 1991 letter from Mr. Ken Cox). The advantages and disadvantages of this option are presented in Section VII.E. Although operating the Ball Mountain Lake project without a conservation pool is feasible, at this time the Corps recommends maintaining the pool. Elimination of the pool does not appear necessary to facilitate effective smolt outmigration and would have major short-term water quality impacts in the West River downstream of the dam. This decision will be reevaluated if new information suggests that maintaining a 25-foot pool has an adverse impact on smolt outmigration.

Effective downstream passage of smolts through Ball Mountain Lake could be provided by construction of a weir at the dam inlet or a smolt capture facility on the West River upstream of the reservoir. Both these options would be much more expensive than the proposed plan. Construction of a weir would also be extremely difficult because of limited access to the dam inlet and water control problems.

III. ENVIRONMENTAL RESOURCES

A. Physical Setting

1. General

Townshend and Ball Mountain Lakes are located on the West River, in southeastern Vermont. The river originates in the town of Mount Holly and flows south-southeast for about 52 miles to its confluence with the Connecticut River in Brattleboro (see Plate 1 in the Specific Project Report). The river basin is generally rectangular in shape, with a length of about 38 miles, and a maximum width of 18 miles. The total basin area is 423 square miles, of which 278 square miles are upstream of Townshend Lake. Topography in the basin is hilly or mountainous, with elevations ranging from 200 feet NGVD at the mouth of the West River, to 3500 feet at several points on the watershed divide. There are few natural lakes in the region.

The West River basin is primarily forested and undeveloped. About 10 percent of the basin is situated in the Green Mountain National Forest. Some agricultural land is present, mostly in flat areas along the West River and its tributaries. Development is largely limited to scattered towns. The population of the basin in 1980 was 8290 (20 persons per square mile). Towns or cities in the basin include Brattleboro, Brookline, Dummerston, Jamaica, Landgrove, Londonderry, Marboro, Peru, Newfane, Stratton, Townshend, Wardsboro, Weston, West Townshend, Windham, and Winhall.

From its source to Ball Mountain Lake (river-mile 29), the West River drops about 1,200 feet, or 52 feet per mile. The gradient is about 34 feet per mile between Ball Mountain Lake and Townshend Lake (river-mile 19.5), and 13 feet per mile between Townshend Lake and the Connecticut River.

Principal tributaries of the West River include the Winhall River, Utley Brook, Ball Mountain Brook, Wardsboro Brook, Whetstone Brook, Greendale Brook, Grassy Brook, and the Rock River. Most of these are upstream of Townshend Lake.

Southeastern Vermont has a continental climate, with long, cold winters and mild summers. Average annual temperatures vary from about 68 degrees in July to 18 degrees in January. The mean length of the frost free season is about 110 days. Freezing temperatures usually occur from late September through early May. Average annual precipitation is 42 inches, and is evenly distributed throughout the year. Snowfall averages about 100 inches per year.

The Townshend and Ball Mountain Lake dams were constructed to desynchronize floodflows of the West River from those on the Connecticut River. The operation of these dams is coordinated with other dams in the Connecticut River Basin to minimize basin-wide flood damages. The dams also provide protection to downstream communities on the West River and provide water-based recreational opportunities.

2. Townshend Lake

Townshend Lake is located on the West River about 19.5 miles above its confluence with the Connecticut River. The dam is a 1,700 foot long rolled earth and rock filled embankment, with a maximum height of 133 feet. Outlet works consist of an intake structure, three 7.5'x 17' control gates, a 540 foot long horseshoe conduit through the dam, and an outlet channel. A weir located upstream of the central flood control gate maintains a permanent conservation pool. The pool has a surface area of 95 acres and a volume of 800 acre-feet. Maximum depth of the conservation pool in summer is 21 feet.

3. Ball Mountain Lake

Ball Mountain Lake is located on the West River about 9.5 miles upstream of Townshend Lake and 29 miles upstream of the Connecticut River. The dam consists of a 915 feet long rolled earth and rockfill embankment, with a maximum height of 265 feet. The outlet works consist of an intake structure with three 5'8" x 10.0' gates, a 864 foot long 13'6' diameter conduit through the dam, and a 32 foot wide discharge channel.

Under present operating conditions a conservation pool is maintained during the summer. The pool has a maximum depth of 65 feet near the intake, a mean depth of 27 feet, an area of 75 acres, a length of about 1.7 miles, and 2,000 acre feet of storage. A small permanent pool is maintained to facilitate gate operations during winter months. The pool has a maximum depth of 25 feet, a surface area of 20 acres, and about 240 acre-feet of storage. During drawdown from the 65-foot stage to the 25-foot stage, about 75 to 100 acres of unvegetated mudflats are exposed.

4. Capture Facility Location

The fish passage facility will be situated about 300 feet downstream of the Townshend Lake outlet (see Plate 8 in the Specific Project Report). At this location, the main West River channel is about 125 feet wide. The substrate consists mostly of cobble, larger rocks, and boulders. A low flow channel is present along the western side of the river. The site was dredged in 1989 and 1990 in order to remove a rocky shoal that was impounding outflow from the dam.

The western embankment of the river grades into a broad, relatively flat floodplain, that was heavily disturbed during construction of the dam. In addition, material dredged in 1989 was placed along this side of the river. A steep embankment is present along the eastern side of the river. Portions of this embankment are severely eroded and some sections have been riprapped.

Outflow from the dam has scoured a deep pool in the river bed immediately downstream of the outlet, and upstream of the proposed capture facility. Ongoing studies are monitoring the stability of the scour hole to insure that the dam outlet structure is not threatened.

B. Hydrology

The West River Watershed has a drainage area of 423 square miles, including 278 square mile upstream of Townshend Lake and 172 square miles upstream of Ball Mountain Lake. Seasonal changes in average outflow from Ball Mountain and Townshend Lakes are presented in Table 1. Minimum flows occur during July, August, and September. Maximum outflow from Townshend Lake is about 9000 cfs.

Table 1: Average flows (cfs) in the West River at Ball Mountain Lake and Townshend Lake.

Month	Townshend*	Ball Mountain**
January	413	257
February	390	280
March	979	544
April	2007	1225
May	900	563
June	360	231
July	184	120
August	140	99
September	181	116
October	283	216
November	497	330
December	505	219

* based on 68 years of record (1919 to 1987) and proportioning flows using the 278/308 drainage area ratio between Townshend Lake and the USGS gage at Newfane, Vermont located 6.8 miles downstream of Townshend Dam.

** based on 41 years of record (1947 to 1987) and proportioning flows using the 172/179 drainage area ratio between Ball Mountain Lake and the USGS gage at Jamaica, Vermont located about 3 miles downstream of Ball Mountain Dam.

Note: Estimates are based on streamflow data for the West River at USGS guaging stations at Jamaica and Newfane, Vermont. The Jamaica station is about 3 miles downstream of the Ball Mountain Lake. Drainage area at the guage is 179 square miles. The Newfane station is about 7 miles downstream of Townshend Lake. The drainage area at this guage is 308 square miles.

C. Water Quality

1. General

Water quality in the West River is rated as class "B" by the Vermont Legislature. Class "B" waters are suitable for bathing, recreation, and irrigation, provide good fish and wildlife habitat, have good aesthetic value, and are acceptable for use in public water supply (with filtration and disinfection). Vermont water quality criteria applicable to Class B waters are summarized in Table 2. Water quality in the West River is generally good, and usually meets these standards (CE, 1983; 1987).

The West River and its tributaries are further designated as Type I and Type II waters. Which particular sections are of the river are Type I or II, however, has not been specified. By definition, Type I waters sustain natural reproducing populations of salmonids, and have dissolved oxygen levels of not less than 7 mg/l at and near spawning areas, and 6 mg/l at all other areas. Type II waters contain mixed populations of brook trout, brown trout and smallmouth bass, and shall not contain less than 6 mg/l dissolved oxygen at all times.

2. Ball Mountain Lake

The 65-foot Ball Mountain Lake pool exhibits weak to moderate thermal stratification in the summer (CE, 1987). Stratification occurs on calm sunny days, but can be broken up by wind action at night, or on cool, cloudy days. In July, water temperature ranges from about 24 to 27^{O}C at the surface to 15 to 21^{O}C near the bottom.

Dissolved oxygen levels in surface waters are generally above 6 mg/l. Thermal stratification results in somewhat depressed dissolved oxygen levels in hypolimnetic (bottom) waters, but anoxic conditions have not been observed in the reservoir. pH ranges between about 5.5 and 7. Levels of most metals (Cd, Fe, Pb, Hg, and Zn) are generally low, and well below criteria established to protect aquatic life. Aluminum levels, however, are above established criteria. Based on total phosphorus levels, which average about 0.013 mg/l, the reservoir can be classified as mesotrophic.

Data collected by the Vermont Fish and Game Department in 1966 suggest that releases from the Ball Mountain Lake conservation pool can reduce the temperature of tailrace waters by as much as 10 degrees ^{O}F (see April 17, 1967 NED memo by R.O. Reiner).

3. Townshend Lake

Dissolved oxygen levels in the reservoir are generally above 6 mg/l (CE, 1983). Somewhat lower levels are occasionally found in bottom waters, but anoxic conditions have not been observed. Based on total phosphorus levels, which average 0.017 mg/l, the reservoir can be classified as mesotrophic. Levels of most metals are generally low, and well below criteria established to protect aquatic life.

Table 2: Vermont Water Quality Criteria.

1. pH: values shall be maintained within the range of 6.5 and 8.0. The change or rate of change in pH either upward or downward resulting from the discharge of wastes shall be controlled so as to prevent any undue adverse effect on aquatic biota, fish, or wildlife.

2. Turbidity:
   a. Cold Water Fish Habitat: not to exceed 10 NTU
   b. Warm Water Fish Habitat: not to exceed 25 NTU

3. Fecal Coliforms: Not to exceed 200 organisms/100 ml except when compliance is waived by permit between October 31 and April 1. Waivers must not result in a health hazard.

4. Color: Not to exceed 25 standard color units.

5. Taste and Odor: None in concentrations that would have an undue adverse effect of beneficial values or uses, or on taste and odor in fish.

Additional criteria applying to all state waters include:

1. Dissolved Oxygen:

   a. Cold Water Fish Habitat: Not less than 7 mg/l or 75 percent saturation at all times, nor less than 95 percent saturation during late egg maturation and larval development of salmonids in areas determined to be salmonid spawning or nursery areas important to establishment or maintenance of the fishery resource. Not less than 6 mg/l or 70 percent saturation at all times in other waters designated cold water fish habitat.

   b. Warm Water Fish Habitat: Not less than 5 mg/l or 60 percent saturation at all times.

2. Temperature: The change or rate of change in temperature, either upward or downward, shall be controlled as to prevent any undue adverse effect on aquatic biota, fish, and wildlife.

3. Nutrients: No increase which would accelerate eutrophication or results in concentrations that may stimulate the growth of aquatic plants, fungi or bacteria in a manner which has an undue adverse effect on any beneficial values or uses.

4. Aquatic Habitat: No change from background conditions which would have an undue adverse effect on the composition of aquatic biota, the physical or chemical nature of the substrate, or the species composition or propagation of fishes.

5. Suspended Solids: None in such concentrations which would have an undue adverse effect on any beneficial values or uses.

4. Capture Facility Location

West River water quality at capture facility location is generally good (CE, 1983). Median dissolved oxygen levels are above 8.0 mg/l, and minimum levels are rarely below 6.0 mg/l. Maximum water temperature at the site is about 26°C.

5. West River Water Temperature[1]

Little data is available concerning West River water temperature during the spring smolt outmigration period (mid April through May). Average daily maximum water temperature at the USGS Newfane, Vermont gaging station during April and May for a six year period (1960-1965) is summarized in Table 3. The earliest dates water temperature reached 5° and 9°C, were April 8 and April 22, respectively. This data may underestimate actual West River water temperature by several degrees because readings were taken from a gaging well, rather than from surface waters.

West River water temperature at the USGS gaging station at Jamaica State Park was above 10°C during the last week of April two out of the four years for which data is available. Water temperature in the West River and major tributaries upstream of Townshend Lake on April 30, 1985 and April 30, 1986 was between 9 and 10.4°C (Vermont River Watch Program; Dan Darrow, pers. commun.). In 1991, West River temperature at Jamaica State Park was consistently above 10°C after April 26 (Laurie Thorpe, pers. commun.).[2]

D. Biological Resources

1. Atlantic Salmon

a. General Life History[3]

Atlantic salmon spawn on gravely substrates in freshwater streams during the fall (mid October to mid November). Eggs are deposited in series of depressions (redds) excavated by females, and then covered by a layer of gravel. After spawning, spent adults (known as kelts) usually return to the ocean or overwinter in freshwater and migrate to the ocean the following spring. Survivorship of kelts is low, and only a small percentage return to freshwater to spawn a second time.

Notes:

1. The timing of Atlantic salmon smolt outmigration is heavily dependant on water temperature. Most studies suggest that smolt outmigration commences when water temperature reaches ca. 5°C. Peak outmigration occurs after water temperature reaches 9-10°C.

2. April of 1991 was the second warmest April on record at the Burlington, VT office of the National Weather Service (average air temperature at Burlington was 4.1°F higher than normal).

3. Based primarily on information contained in Mills (1989) and Danie et al. (1984).

Table 3: Average Maximum Daily Water Temperature (^{o}C) at U.S.G.S Newfane, Vermont Gaging Station (1960-1965).

Day	Month	
	April	May
1	1.8	9.4
2	1.5	9.1
3	1.5	9.6
4	1.6	10.5
5	1.9	10.8
6	2.1	12.1
7	2.4	12.0
8	3.3	12.0
9	3.3	12.1
10	3.8	12.1
11	3.4	13.0
12	3.9	12.7
13	3.9	12.9
14	4.3	13.4
15	4.2	13.4
16	4.4	13.8
17	4.4	14.6
18	4.7	15.5
19	4.7	15.2
20	5.2	14.7
21	6.3	15.1
22	6.6	15.2
23	6.7	14.9
24	6.3	14.9
25	6.3	15.6
26	6.6	16.5
27	7.0	16.7
28	7.8	16.8
29	8.5	16.9
30	9.1	17.1
31	-	17.1

Eggs incubate in gravel over winter, and hatch during April through early June. After hatching, larvae remain buried in gravel for about 6 weeks, while slowly absorbing attached yolk sacks. Young salmon (known as fry) emerge from redds in early summer, disperse, and establish territories. Once fry become about 40 mm long they are known as "parr".

In Vermont, most parr remain in freshwater for 2 years before developing into "smolts" and migrating to the ocean. During the smoltification process, parr develop a silvery pigmentation, tolerance to salt water, and schooling behavior. Parr that reach a length of 125-150 mm by spring or early summer of a given year, generally transform into smolts and migrate to the ocean the following spring. The timing of the spring smolt migration is thought be largely a function of water temperature. Although some outmigration occurs once water temperature reaches $5^{o}C$, migration begins in earnest when water temperature rises above $9-10^{o}C$. Smolts which are unable to migrate to the sea transform back into parr, and spend an additional year in freshwater.

Atlantic salmon from northeastern U.S. rivers migrate to North Atlantic waters near Greenland and Labrador. After spending 1-3 years at sea, most return to their natal stream to spawn. Adults that return after one year at sea are known as "grisle", and weigh 1-3 kg. Those returning after 2-3 years at sea are known as "bright salmon", and typically weigh 3-9 kg.

Returning adults typically enter estuarine waters in the spring. Although most migrate upstream in early summer (May, June), some remain in estuaries through summer, and migrate upstream during the fall. Once salmon reach natal streams they tend to remain inactive in deep pools until spawning. Adults do not feed in freshwater.

b. Connecticut River Population

The Connecticut River basin once supported one of the largest Atlantic salmon fisheries in North America. Salmon were eliminated from the upper river by a dam built at Turners Falls, Massachusetts in 1798. The dam prevented adult salmon from reaching upstream spawning grounds, including the West River and its tributaries. A concerted effort to restore salmon to the Connecticut River in the mid-late 1800s failed because of ineffective fish passage facilities and continued dam construction (Stolte and Rideout, 1989).

Current restoration efforts date from passage of the Anadromous Fish Conservation Act in 1965 (P.L. 89-304), and establishment of the Connecticut River Anadromous Fish Program in 1967. The goal of the program is: "To provide and maintain a sport fishery for Atlantic salmon in the Connecticut River Basin and to restore and maintain a spawning population in selected tributaries" (Stolte, 1982).

To accomplish this goal, efforts have focused on construction of fish passage facilities on mainstem Connecticut River dams and on intensive stocking of major tributaries with hatchery reared fry, parr, and smolts. To date, fish passage facilities have been constructed at five mainstem Connecticut River dams, including all those below the confluence with the West River. In recent years (1987-1989) nearly 4 million hatchery reared fry and 1.5 million juveniles (parr and smolts) have been released in the basin.

An average of about 210 adult salmon have returned to the Connecticut River over the last five years (1986-1991). Virtually all returning adults are captured in fish passage facilities, and retained for propagation purposes. Much larger returns are anticipated in coming years as a result of heavy fry stocking since the late 1980's. Potential reasons for poor returns to date include fishing pressure in the North Atlantic and smolt mortality during downstream passage through mainstream Connecticut River hydropower dams.

c. West River Population

Although historical records are scant, the West River apparently once supported a large Atlantic salmon population. Stolte (1982) provides a quote from the book "Life Along the Connecticut River":

> "... a word about fishing, for at the junction of the West River there was a rendezvous of the Squakheag Indians-- the name meaning "salmon spearing place". The story is that salmon once ran so thick that one could almost walk across the river on their backs".

The West River is ranked third among Connecticut River tributaries with respect to potential output of wild salmon smolts (Stolte, 1982). Estimated potential wild smolt production from the river is 43,000 to 90,000. About 80 percent of West River smolt habitat is upstream of the Townshend Lake. Based on potential smolt output from the basin, eventually at least 550 salmon per year are projected to return to the river (Westerling, 1984).

Although fish passage facilities on the Connecticut River provide adult salmon access to the West River, few spawning adults currently return to the river. Virtually all salmon migrating to the upper Connecticut River are captured at the Holyoke Dam and retained for propagation purposes. Some fish are released above Holyoke, however, and in recent years a few Atlantic salmon have entered the West River. At least one salmon was seen in the pool immediately downstream of Townshend Lake in May of 1990 and two unconfirmed sightings were reported from the West River in 1991. In the next several years much larger returns of adult salmon are anticipated in the Connecticut River. If these projections are correct, substantial numbers of salmon will probably enter the West River. Peak migration of adults into the West River will probably occur between late May and early June, with 85-90 percent of fish likely to enter the river by the end of July (Larry Bandolin, U.S. FWS, person. commun.).

No significant natural reproduction of Atlantic salmon currently occurs in the West River. Large numbers of fry, however, have been released into the basin since 1987. In 1991 about 543,000 fry were released in the basin. About 50 percent of these were released above Ball Mountain Lake, and 80 percent above Townshend Lake (Jay McMenemy, Vermont Dept. of Fish and Wildlife, pers. commun.). Tributary streams stocked with fry include the Winhall River (Cook Brook and Mill Brook), Glendale Brook, Flood Brook, Utley Brook, Ball Mountain Brook, Wardsboro Brook, and the the Rock River (Marlboro Brook). About 20,000 hatchery reared smolts are also released annually below Townshend Lake.

Surveys conducted by the Vermont Department of Fish and Wildlife indicate that fry survival to the yearling parr stage in West River tributaries is generally excellent (see McMenemy, 1989). No information is yet available, however, concerning actual smolt outmigration from the basin.

2. Other Aquatic Life

Table 4 provides a list of fish likely to occur in the West River basin. Common species at the capture facility site include brown trout, rainbow trout, fallfish, common shiner, blacknose dace, bass, and white sucker.

Fair Brook, a small tributary which enters the West River just downstream of the capture facility site, supports spawning populations of brook trout. Cool waters from Fair Brook also probably provide a refuge for other salmonids during summer months when stream temperatures in the West River are high.

Both Townshend and Ball Mountain Lake support limited warmwater fisheries. Predominant species present in Townshend Lake include rainbow trout (stocked), yellow perch, rock bass. Smallmouth bass, largemouth bass, bullhead, and sunfish are also found in the lake. Game fish found in Ball Mountain Lake include rainbow trout, brown trout, and perch. Rainbow trout are stocked in the lake by the Vermont Department of Fish and Wildlife on a put and take basis. Brown trout are stocked in the West River below Ball Mountain Lake.

Aquatic invertebrates occurring in the West River at the capture facility site include stoneflies, mayflies, caddisflies, and aquatic dipterans. The invertebrate community is somewhat depauperate, and may still be recovering from dredging operations conducted at the site in 1989 and 1990.

Although no freshwater mussels occur at the capture facility site, several species are present about 2,000 to 3,000 feet downstream. These include the brook floater, a candidate species under the Federal Endangered Species Act (see the "Threatened and Endangered Species" section of this report).

Table 4: Common Fish Present in the West River

common name	scientific name
American eel	Anguilla rostrata
Atlantic salmon	Salmo salar
blacknose dace	Rhinichthys atratulus
brook trout	Salvelinus fontinalis
brown bullhead	Ictalurus nebulosus
brown trout	Salmo trutta
carp	Cyprinus carpio
common shinner	Notropis cornutus
creek chub	Semotilus atromaculatus
fallfish	Semotilus corporalis
large mouth bass	Micropterus salmoides
longnose dace	Rhinichthys cataractae
longnose sucker	Catostomus cataractae
mimic shiner	Notropis volucellus
northern pike	Essox lucius
rainbow trout	Salmo gairdneri
rock bass	Ambloplites rupestris
sea lamprey	Petromyzon marinus
small mouth bass	Micropterus dolomieui
walleye	Stizostedion vitreum
white perch	Morone americana
white sucker	Catostomus commersoni
yellow perch	Perca flavescens

Table 5: Riparian Vegetation Present Near the Proposed Capture Facility Location.

common name	scientific name
alder	Alnus rugosa
willow	Salix sp.
sycamore	Platanus occidentalis
sumac	Rhus typhina
autumn olive	Elaegnus umbellata
gray birch	Betula
white birch	Betula papyrifera
Rose (vine)	Rosa sp.
meadow sweet	Spiraea latifolia
hardhack	Spiraea tomentosa
goldenrod	Solidago sp.
reed canary grass	Phlaris arundinaceae
sensitive fern	Onoclea sensibilis
Aster	Aster sp.
milkweed	Asclepias incarnata
bramble	Ribes sp.
unidentified grasses	

3. <u>Vegetation</u>

Most of the West River basin is forested. Predominant species occurring at low elevations include sugar maple, red maple, yellow birch, white birch, red oak, beech, ash, white pine, and hemlock. Red, white, and black spruce and balsam fir are predominant at higher elevations.

At Ball Mountain Lake no vegetation occurs below the 65-foot pool stage (the normal summer pool level). Vegetation between the 65-foot stage and 80-foot stage is dominated by grasses, willows and other low shrubs. Above the 80-foot stage the reservoir is forested predominately by red maple, sugar maple, white birch, yellow birch, red oak, American beach, white ash, aspen, red spruce, and white pine.

Townshend Lake has a moderate amount of submerged aquatic vegetation growing in shallow areas. Scrub-shrub vegetation dominated by alder is common along the margins of the normal 21-foot pool. Extensive wetlands dominated by grasses, sedges, and alder are present at the head of the pool. The reservoir is forested above about the 30 to 35-foot stage with species similar to those at Ball Mountain Lake.

Riparian vegetation near the proposed Townshend Lake capture facility is dominated by low shrubs (alder, willow, and autumn olive). A list of species occurring at the site is presented in Table 5.

4. <u>Wildlife</u>

Mammals likely to occur near the Townshend Lake capture facility include white tailed deer, fox, fisher, mink, muskrat, and otter. Otter, mink, white tailed deer, and raccoon commonly occur at Ball Mountain Lake.

Numerous species of birds are likely to occur at Ball Mountain and Townshend Lakes. Common mergansers are abundant at both lakes. Other waterfowl present include mallards, canvasbacks, cormorants, great blue heron, and hooded mergansers. Osprey have been observed at both areas and are the focus of a reintroduction effort by Corps personnel.

A variety of birds are likely to occur in scrub-shrub habitat near the Townshend Lake capture facility. These include tree swallow, mourning doves, kingfisher, blue jay, eastern kingbird, eastern phoebee, black capped chickadee, catbird, mockingbird, yellowthroat, red winged blackbird, American goldfinch, and song sparrow.

5. Threatened and Endangered Species

Several species of rare or threatened freshwater mussels are known to occur in the West River (see June 12 and June 18 letters from Chris Fichtel, Vermont Natural Heritage Program, and March 14 and December 10 letters from Gordon Beckett, U.S. Fish and Wildlife Service).

A field survey conducted on June 7, 1991 found no mussels at the capture facility site. The substrate at the site is rocky and provides poor mussel habitat. The nearest suitable mussel habitat is situated about 2000 feet downstream of the site (just downstream of Scott's Covered Bridge). Four species of mussels were found at this location:

Elliptio complanata	(Eastern elliptio)
Strphitus undulatus	(Squawfoot)
Lampsilis radiata	(Eastern Lamp Mussel)
Alasmidonta varicosa	(Brook Floater)

The brook floater is a proposed threatened species in Vermont, and is "candidate species" for inclusion on the Federal list of threatened and endangered species. Brook floaters were most common in a sandy backwater area along the west side of the river, about 100 to 300 feet downstream of the bridge. The other three species are relatively common, and not considered rare, threatened, or endangered by the Federal government or Vermont. A second brook floater population is reportedly present about 4.5 miles downstream of Townshend Lake.

Freshwater mussels are not abundant in the West River between Townshend and Ball Mountain Lakes. The substrate along much of this reach is rocky, and provides poor mussel habitat. The brook floater and eastern pearl mussel (Margariterfera margaritifera), however, are known to occur near the confluence with Wardsboro Brook, about 5 miles downstream of Ball Mountain Lake. The Eastern pearl mussel is currently proposed for threatened status in Vermont.

With the exception of transient bald eagles and peregrine falcons no other Federal or state listed rare, threatened, or endangered species are known to exist in the project area.

E. Historic and Archeological Resources

The proposed site for the capture facility was extensively disturbed by construction of Townshend Dam, which was completed in 1961. The Cultural Resource Management Study (Thomas and Bourassa 1986), determined that the area around the dam and outlet structures had no archaeological potential.

A Cultural Resource Management Study for Ball Mountain Lake was completed in 1982 (Thomas and Warren 1982). This study identified two areas that could be affected by pool fluctuations. One area was a large terrace, normally below the level of the summer reservoir, the location of find spot, WD-FS-3 (Thomas and Warren 1982: 98). One bifacially worked quartzite cobble was found on the surface during a walkover of the terrace.

The second area was a small terrace at the northern edge of the summer pool (870.5 ft. MSL). Further investigations were performed at this location in 1984, as part of a proposed plan to convert the dam to produce hydroelectric power, and prehistoric site VT-WD-36 was identified (Thomas and Warren 1984). It was determined that site VT-WD-36 met the eligibility criteria for nomination to the National Register of Historic Places. A short-term monitoring program implemented by the Corps at that time did not identify any significant terrace erosion at VT-WD-36. Management considerations for this area, if the hydroelectric facility was constructed, were to develop a long-term erosion monitoring program for this terrace.

F. Social and Economic Resources

Townshend and Ball Mountain Lakes are located in a largely rural area of southeastern Vermont. Much of the area is forested and undeveloped. Principal towns near the Lakes include Townshend, Jamaica, and Newfane. Brattleboro, the 8th largest city in Vermont, is located about 30 miles southeast of Townshend Lake. Several major population centers (Boston, Massachusetts; Concord, New Hampshire, Albany, New York; and Hartford, Connecticut) are within a three hour drive of the area. Vermont Route 30, parallels the West River, and provides easy access to both projects from Brattleboro.

The local economy is dependent on the forest products and tourist industries. Tourism is largely based on sight-seeing during the summer and fall, and downhill skiing during winter months. Recreational opportunities at Ball Mountain and Townshend Lakes and the nearby Jamaica Sate Park also draw many visitors to the area. Controlled releases from Ball Mountain Lake during several weekends during the spring and fall (see below) attract hundreds of white water canoeists and kayakers. Numerous retail shops, motels, and restaurants are present in the area, and are heavily dependent on tourism. Manufacturing, construction, and agriculture play a relatively minor role in the local economy.

Recreational facilities available at Townshend Lake include a swimming beach, picnic areas, hiking trails, and a boat ramp. Total 1990 visitation at Townshend Lake was 428,254 visitor hours. Principal activities were sight-seeing, picnicking, and swimming. The Townshend Lake outlet is a popular fishing spot for trout and other gamefish. Facilities available at Ball Mountain Lake include hiking trails, a picnic ground near the dam, and a large campground located about two miles upstream of the dam. Total 1990 visitation at Ball

Mountain Lake was 395,800 visitor hours. Principal activities were sight-seeing, and camping. Little swimming, fishing or boating occurs at Ball Mountain Lake.

Each year the Corps provides controlled releases (1500 cfs) from Ball Mountain Lake for whitewater canoeing and kayaking. Prior to 1990, controlled releases were typically made during two weekends in the spring (late April and early May) and during Columbus Day weekend in October. The releases provide outstanding white water conditions between Ball Mountain and Townshend Lakes, and attract hundreds of white water enthusiasts each year. National White Water Canoeing Championship races were frequently held in the West River during one of the spring release weekends. Since the fall of 1990, there has been an informal agreement between the Corps, U.S. Fish and Wildlife Service, Vermont Department of Fish and Wildlife, and the Appalachian Mountain Club to have only one spring release, dedicated for recreational purposes. Races were held elsewhere in 1991, and are not currently scheduled to be held at Ball Mountain Lake in future years.

IV. ENVIRONMENTAL CONSEQUENCES

a. Aquatic Habitat

1. Capture Facility

Construction of the capture facility would require excavation of several thousand cubic yards of rock and gravel from the West River. The material would be placed at an existing upland disposal site. Several thousand square feet of natural river bottom would be replaced by the barrier, in-stream trap, and associated scour protection. About 0.1 acres of riparian habitat would be altered during construction of the facility and access road. Although most of this area has previously been disturbed, several hundred square feet of vegetated habitat would be lost. Some additional aquatic habitat would also be disturbed by the coffer dams.

It will be necessary to use Townshend and Ball Mountain Lakes to regulate West River flow during construction. This may result in somewhat more variable flow in the river than normal, and have a minor short-term adverse impact on habitat quality. The normal 65-foot summer pool at Ball Mountain Lake will not be maintained during construction, and both Ball Mountain and Townshend Lake pools will be subject to more extreme fluctuations than normal. There is no practical alternative to use of the reservoirs to control West River flows during construction. Construction of higher cofferdams to fully protect against flows likely to occur during construction is not practical due to engineering constraints.

Occasional reductions in outflow from Townshend Lake or Ball Mountain Lake during construction could dewater West River aquatic habitat located downstream of the dams. Efforts will be made to minimize disruption of downstream habitat by using cofferdams at

Townshend Lake, by maintaining a minimum flow of at least ca. 90 cfs (or inflow if less) at both dams, by gradually making changes in flow (especially below 200 cfs), and by conducting in-stream work during the low flow season as much as possible.

2. Ball Mountain Lake Regulation

Changes in regulation of Ball Mountain Lake to enhance smolt passage would result in temporary loss of some aquatic habitat during the spring and early summer. Under the proposed plan, restoration of the 65-foot pool would be delayed from April (as under current operating procedures) until June 1. In most years inflow to the reservoir would be sufficient to quickly restore the 65-foot pool after June 1. In exceedingly dry years, however, sufficient inflow may not be available to restore the 65-foot pool until much latter in the summer. This temporary loss of aquatic habitat is undesirable, but is not considered to be significant. No vegetated wetlands would be impacted. Even partial restoration of the 65-foot pool during early summer should insure that cool outflow from the reservoir would moderate West River water temperature downstream of the dam.

Maintenance of a 25-foot pool, rather than a 65-foot pool, during the smolt outmigration period would result in increased erosion of sediments from exposed mudflats in the reservoir. Because most of these sediments would probably be retained by the 25-foot pool, impacts on West River habitat quality downstream of the dam would be slight.

B. Water Quality

1. Capture facility

In-stream work during construction of the capture facility will temporarily increase suspended sediment levels in the West River for a short distance downstream of the work area. Impacts should be minimal because the substrate consists primarily of rock and coarse sediments with low fines content. Use of cofferdams during construction, and conducting in-stream work during low flow periods, will also minimize water quality impacts.

Maintaining the Ball Mountain pool at 25-foot during construction, rather than the normal 65-foot stage, would expose large mudflat areas to erosion during storm events. Water quality monitoring during a storm event found that maintaining a 25-foot pool had no measurable impact on turbidity downstream of the dam.

Operation and maintenance of the capture facility would have no long-term adverse impact on West River water quality.

2. Ball Mountain Lake Regulation

Maintenance of a 25-foot pool at Ball Mountain Lake during the smolt outmigration period, rather than a 65-foot pool, could slightly increase turbidity downstream of the dam during storm events. As discussed above, however, monitoring during a 1990 storm event found that maintenance of a 25-foot pool resulted in no measurable impact on turbidity downstream of the dam.

Lowering the Ball Mountain pool to 25-foot during late April and May should have no impact on West River water temperature downstream of the dam. Restoration of the 65-foot pool during summer will insure that cool outflow from the reservoir will continue to moderate tailrace water temperature.

C. Biological Resources

1. Atlantic Salmon

a. Capture Facility

The proposed facility will insure passage of adult salmon upstream of Townshend and Ball Mountain Lakes. Virtually all adult salmon that reach Townshend Lake should be trapped, and successfully transported upstream. Salmon mortality caused by handling and transport is expected to be negligible.

Some adult Atlantic salmon may be present in the pool immediately downstream of Townshend Lake during construction of the capture facility. If significant numbers of salmon are thought to be present in the pool, attempts will be made to capture them with nets or by electroshocking. All captured salmon will be released upstream of Townshend Lake.

b. Ball Mountain Lake Regulation

Maintaining a 25-foot pool at Ball Mountain Lake during the smolt outmigration period will insure that smolts pass through the dam with minimal delay or mortality. This conclusion is supported by Corps funded U.S. FWS studies using radio tagged smolts conducted in 1990 and 1991 (see Appendices C and D of the Site Specific Project Report). Both studies found that smolts quickly pass through Ball Mountain Lake (with a 25-foot pool), with average delays of 2 to 6 hours. Delays of this order are not considered biologically significant. The 1991 studies suggest that smolts passing through the dam (with a 25-foot pool) probably suffer little (< 10 percent) mortality. The studies also found that the permanent pool at Townshend Lake does not significantly delay smolt outmigration.

The proposed period for maintaining a 25-foot pool at Ball Mountain Lake (late April through May) should normally encompass most of the peak smolt outmigration period. Some smolts may migrate earlier in April, however, particularly during unusually warm years. Passage of these fish will probably be delayed until the reservoir is

drawn down during late April in conjunction with whitewater releases. Although this delay is not considered significant, it is likely that fish passing through the reservoir during the whitewater releases will suffer substantial mortality due to pressure effects and abrasion. If future studies find that a significant percentage of smolts migrate downstream prior to the late April whitewater releases, a further adjustment in reservoir operation will be considered.

Some smolts may be injured during passage through the fish barrier at the Townshend Lake capture facility. Projected approach velocities at the barrier will sometimes exceed 3 fps, and could cause impingement of smolts passing downstream while the barrier is in place. Because the barrier will not be in place until well after peak smolt outmigration, barrier impacts on smolts should be minimal.

2. Other Aquatic Life

a. Capture Facility

During construction of the capture facility fish and other aquatic life near the work area will be displaced. Some mortality of fish eggs, fry, and invertebrates may occur due to desiccation or burial by fill. Impacts on downstream aquatic life due to sedimentation or suspended sediments should be minimal because of the coarse nature of bottom sediments in the work area. Biota will quickly recolonize disturbed areas following completion of the facility.

Changing flows in the West River during construction may have a minor impact on fish eggs, fry and invertebrates occurring downstream of Ball Mountain and Townshend Lakes (see also Section IV.C.5 for a discussion of impacts on freshwater mussels). To minimize impacts to aquatic life downstream of both projects, a minimum flow of 90 cfs, or inflow if less, will be maintained during project construction to the maximum practical extent. Any reductions in outflow below 200 cfs at Townshend or Ball Mountain Lakes will be made gradually to minimize stranding of downstream aquatic life.

Fluctuations in Townshend Lake levels could adversely impact eggs and fry of bass and other fish. Maintaining at 25-foot pool at Ball Mountain Lake, rather than 65-foot, during construction may result in loss of normally cool outflow from the reservoir, and could have a minor adverse impact on the brown trout fishery in the West River immediately downstream of the dam.

Operation of the capture facility should have no significant impact on the existing fish community at the site. The trap will occasionally catch resident species such as brown trout. These fish will be released from the trap and will not transported upstream with the salmon. The fish barrier should have no significant impact on movements of fish occurring in the river. Some impingement of smaller fish may occur while the barrier is in place when flows exceed 2-3 fps.

There is some evidence that reintroduction of salmon in rivers and streams may lead to the decline of other salmonid populations due to competition (see Hearn, 1987). In the West River, populations of brook trout and brown trout could be effected by Atlantic salmon restoration efforts. Impacts to trout resulting from salmon reintroduction will occur, however, as a result of continued fry stocking with or without the proposed Corps project.

In addition to Atlantic salmon, the Townshend Lake facility will probably capture some adult sea lamprey. Unless lamprey are selectively removed from the trap prior to upstream transport, operation of the facility will result in reintroduction of these fish upstream of Townshend Lake. Sea lamprey are native to the West River basin, but are currently not present upstream of Townshend Lake. Accidental reintroduction of lamprey above Townshend Lake would pose no threat to existing fisheries resources in the river. Adult lamprey die soon after spawning and do not feed while in freshwater. Juveniles feed exclusively on benthic prey.

b. Ball Mountain Lake Regulation

Changes in regulation of Ball Mountain Lake to enhance smolt passage will have little adverse impact on existing aquatic life in the reservoir. Under current operating conditions the existing fishery and invertebrate community is already disturbed each year when the 65-foot pool is dropped to 25-foot during the late fall, winter, and early spring. The proposed delay in reestablishing the pool until June 1, rather than in April, should have little additional adverse impact on aquatic life. The State of Vermont will continue to stock Ball Mountain Lake, but will delay stocking until after the 65-foot pool is restored.

Any slight increases in silt transport from Ball Mountain Lake caused by the proposed reservoir regulation plan would have no significant impact on brown trout or other species which spawn in the West River downstream of the dam.

3. Vegetation

a. Capture Facility

A small amount of riparian vegetation (<0.1 acre) at the capture facility site would be lost during construction. This impacts is unavoidable and has been minimized to the greatest practical extent.

Use of Ball Mountain and Townshend Lakes to regulate West River flow during project construction could have an adverse impact on trees and shrubs growing within both reservoirs. Of most concern is the potential impact to trees, if inundation occurs during the growing season. Flooding impacts on trees at Ball Mountain Lake were well documented in a study conducted after prolonged (8-15 days) inundation in June and July of 1973 (McKim et al., 1975). Inundation resulted in substantial defoliation and tree mortality. Most sensitive species were white pine, aspen, red spruce, hemlock, and birch.

The impact of inundation on trees during construction of the capture facility is difficult to predict. If construction occurs during a relatively wet year, and trees are frequently flooded during the growing season, or flooded for an extensive period due to a major event, substantial defoliation and mortality might occur. If construction occurs during a relatively dry year, little inundation or mortality would occur. Potential impacts during a wet year may be mitigated somewhat by the fact that previous flooding at the reservoir (including 1973, 1976, and 1984 events that occurred during the growing season) has probably selected for relatively flood tolerant species. Impacts found by McKim et al. (1975) may have been particularly severe because the 1973 event was the first major flood that occurred during the growing season after construction of the reservoir. Also, it is unlikely that vegetation will be flooded for more than a few days under the proposed water control plan, compared to 8 to 15 days during the 1973 flood. Measures will be taken to minimize flooding of forested areas above the 80-foot stage at Ball Mountain Lake and the 30 to 35-foot stage at Townshend Lake.

Short-term inundation could also result in some defoliation or mortality of grasses and other emergent vegetation at Townshend Lake. Impacts are difficult to predict since little is known about the short-term flooding tolerance of emergent species. Once again the severity of impacts would depend on the frequency and magnitude of storage events during the growing season. Emergents should be tolerant of prolonged inundation prior to and after the growing season. Submerged aquatic plants at Townshend Lake should not be severely impacted by short-term exposure to increased water depths.

b. Ball Mountain Lake Regulation

Changes in regulation at Ball Mountain Lake for smolt passage should have no significant impact on riparian vegetation occurring along the periphery of the reservoir.

4. Wildlife

a. Capture Facility

Wildlife occurring near the proposed capture facility and in areas inundated as a result of the water control plan will temporally be displaced during construction. Displaced animals would probably be subjected to somewhat higher mortality due to dispersal related stress and loss of optimal habitat. No nestling mortality should occur among birds since fledging will have occurred prior to construction. Cavity nesting birds such as chickadees and woodpeckers would benefit in the long-term due to increased snag availability if any trees are killed by flooding.

b. Ball Mountain Lake Regulation

Lowering Ball Mountain Lake to facilitate downstream smolt passage could have a minor impact on merganser nest site selection. Although no inventory of nest sites at the reservoir is available, mergansers generally prefer tree cavities close to water. Nest site selection occurs during late April and early May. Under the proposed

regulation scheme, some nest sites normally selected when a 65-foot pool is maintained might be rejected because they would be too far open water provided by the 25-foot pool.

Atlantic salmon restoration efforts in the West River basin have conflicted with ongoing efforts to restore osprey in the area. Fisheries managers have expressed concerns that osprey may prey upon a significant number of salmon smolts. Given the large population of smolts in the basin, and heavy existing predation by mergansers, however, added predation pressure by several pairs of osprey would not be significant.

5. Threatened and Endangered Species

a. Capture Facility

Operation of the Townshend Lake capture facility should have no significant impact on any species considered threatened or endangered by the U.S. Fish and Wildlife Service or the State of Vermont (see March 14 and June 18, 1991 letters from Gordon Beckett, U.S. FWS; and June 12 and 13 letters from Chris Fichtel, Vermont Natural Heritage Program).

Construction of the capture facility does, however, have the potential to impact a population of brook floater, a rare freshwater mussel (and potential Federally listed threatened or endangered species) found at the Scott's Bridge site, 2,000 to 3,000 feet downstream of Townshend Lake. Of principal concern is the possibility that rapid reductions in outflow from the dam will dewater mussel habitat, and result in mortality of stranded mussels due to overheating, desiccation, or predation. The potential for stranding mussels below Townshend Lake was clearly demonstrated on July 10, 1990 when numerous mussels (including brook floater) were stranded as outflow from the dam was reduced from ca. 90 to ca. 50 cfs over a several hour period. Substantial mussel mortality was avoided by manually transplanting stranded individuals to deeper water.

To minimize mussel stranding, a minimum flow of ca. 90 cfs at Townshend Lake (or inflow into the reservoir if less) will be maintained during project construction to the maximum practical extent. A rate of 90 cfs will insure that most available mussel habitat downstream of Scott's Bridge remains submerged. As an added precaution, any reductions in flow below 200 cfs will be made gradually over a 12-24 hour period. Monitoring will be conducted to determine if this protocol is adequate to prevent stranding. Stranded mussels found during monitoring will be transplanted to deeper water. Measures taken to protect the Scott's Bridge brook floater population should also protect any other populations occurring further downstream.

b. Ball Mountain Lake Regulation

Changes in operation of Ball Mountain Lake to enhance smolt outmigration should have no impact on any species considered threatened or endangered by the U.S. Fish and Wildlife Service or the State of Vermont.

D. Historic and Archaeological Resources

1. Capture Facility

The proposed site for the capture facility was extensively disturbed by construction of Townshend Dam. The Cultural Resource Management Study (Thomas and Bourassa 1986), determined that the area around the dam and outlet structures had no archaeological potential. It is anticipated that construction of the capture facility should have no effect upon any structure or site of historic, architectural or archaeological significance as defined by the National Historic Preservation Act of 1966, as amended. The Vermont State Historic Preservation Officer (VT SHPO) has concurred with this determination.

2. Ball Mountain Lake Regulation

The terraces identified by the cultural resource management study for Ball Mountain Lake (Thomas and Warren 1982) as areas that could be affected by pool fluctuations, were further investigated. On the north side of the West River, six core samples were taken in the general location of the "find spot" identified in the 1982 report (WD-FS-3). The limiting depth of the corer was 120 cm. All six samples demonstrated alluvium up to 120 cm. There does not appear to be any actively eroding areas on this terrace. Any prehistoric sites which may be present in this location would be protected from disturbance by the depth of alluvium. Therefore, no further work was recommended for this area, unless erosion begins to occur.

Three core samples were taken to determine the depth of alluvium, along the terrace containing site VT-WD-36, which meets the eligibility criteria for the National Register of Historic Places (Thomas and Warren 1984: 36). All three samples demonstrated that the silt is 85-90 cm deep, slightly deeper than it was when the site evaluation was performed in 1984 (Thomas and Warren). This alluvium is protecting the site from erosion. However, some erosion could be occurring along the edge of the terrace bordering the West River, due to reservoir fluctuations. Therefore, a long-term monitoring plan was implemented by the Corps.

Thirteen, 2 foot stakes were placed along the terrace at 1.0 meter intervals, beginning approximately 10 meters from the edge of the terrace and extending about 2 meters down the embankment facing the West River. Three other stakes were randomly placed in unobtrusive locations to protect against vandalism and their distance from the reservoir edge were noted. The area will be monitored periodically (3-4 times per year, more often after significant flood storage) to determine if, or how rapidly erosion is occurring. If erosion is significant (greater than three meters along the embankment of the West River, within the first year), then site stabilization will be accomplished.

With the implementation of the erosion monitoring plan, the Corps believes that the proposed project should have no effect upon any structure or site of historic, architectural or archaeological significance as defined by the National Historic Preservation Act of 1966, as amended. The Vermont State Historic Preservation Officer has concurred with this determination.

E. Social and Economic Resources

1. Capture Facility

Implementation of the water control plan may result in periodic flooding of the Townshend Lake recreation area. If flooding occurs frequently, the facility may be closed for the season. The normal fall releases from Ball Mountain Lake for white water recreation may be precluded due to construction in 1992.

After the capture facility becomes operational, the state of Vermont will probably prohibit fishing within about 200 to 300 feet of the facility from mid May through November. This reach of the river is on Federal land, and is presently a popular fishing spot.

Restoration of adult salmon in the upper West River basin could create an opportunity for a late fall or spring kelt fishery (kelts are adult salmon following spawning). The State of Vermont would probably sanction this fishery, since the likelihood of kelts migrating successfully downstream through mainstem Connecticut River dams and returning to the West River to spawn in subsequent years is very low. Eventually a much more valuable fishery for "bright salmon" (2-3 year old adult salmon returning to spawn) might also be established.

The capture facility will attract additional visitors to the area, and provide an excellent opportunity for the Corps to educate the public about Atlantic salmon and the Connecticut River salmon restoration program.

2. Ball Mountain Lake Regulation

Proposed changes in regulation of Ball Mountain Lake to enhance smolt passage will result in the loss of one of the two spring weekends traditionally dedicated for whitewater recreation. At present, it appears that releases for general whitewater recreation will be made on the remaining weekend, and that National Whitewater Canoe Championships will no longer be held on the West River. If future studies find that substantial smolt outmigration occurs earlier than currently supposed, the remaining spring whitewater releases may have to be rescheduled or canceled. As returns of adult salmon increase, the State of Vermont may eventually request that traditional fall whitewater releases no longer be allowed during the salmon spawning season. Although other rivers are available for white water recreation in Vermont, regulated releases from Ball Mountain Lake provide exceptional whitewater conditions that will be difficult to replace.

Delayed restoration of a 65-foot pool at Ball Mountain Lake until June will have a minor aesthetic impact due to prolonged exposure of extensive, unsightly, mudflats.

V. ACTIONS TAKEN TO MINIMIZE ADVERSE ENVIRONMENTAL CONSEQUENCES

1. Adverse construction impacts on water quality and aquatic life will be minimized by employing proper erosion and sedimentation control measures. In-stream work will be conducted as much as practicable in the dry using cofferdams, and during low flow months.

2. Construction equipment will avoid riparian areas to the maximum practicable extent. Work limits and sensitive riparian areas will be flagged prior to construction.

3. Fluctuations in pool levels at Ball Mountain and Townshend Lakes during construction will be minimized as much as possible to avoid impacts to riparian areas and wetlands, archaeological resources, and Townshend Lake recreation facilities.

4. Efforts will be made during construction to minimize stranding of mussels and other aquatic life downstream of the Townshend and Ball Mountain Lakes. A minimum flow of ca. 90 cfs (or inflow into the reservoirs if less) will be maintained at both reservoirs during project construction to the maximum practical extent. Any reductions in flow below 200 cfs will be made gradually over a 12-24 hour period. A rate of 90 cfs will insure that most available mussel habitat downstream Townshend Lake is submerged. Monitoring will be conducted to insure that this protocol is adequate to protect mussel populations. A similar protocol will be followed during maintenance of the capture facility, including installation and removal of the fish barrier.

5. A monitoring plan will be implemented at Ball Mountain Lake to insure that reservoir operation during construction of the capture facility and regulation for smolt outmigration does not exacerbate stream bank erosion at an archaeological site.

6. Measures will be taken by State and Federal resource agencies and the Corps to obtain data concerning the timing of smolt outmigration in the West River. Such information is needed to determine if the current smolt outmigration "window" is adequate, or needs to be modified. If significant smolt outmigration is regularly found to occur earlier than the last weekend in April, strong consideration will be given to rescheduling or canceling Ball Mountain Lake releases for whitewater recreation.

VI. REFERENCES

Danie, D.S., J.G. Trial, and J.G. Stanley. 1984. Atlantic Salmon (Species Profiles: Life Histories and Environmental Requirements of Coastal fish and Invertebrates (North Atlantic)). U.S. FWS Report FWS/OBS-82/11.22. Washington D.C.

Hearn, W.E. 1987. Interspecific competition and habitat segregation among stream-dwelling trout and salmon: a review. Fisheries 12: 24-31.

McKim, H.L., L.W. Getto, and C.J. Merry. 1975. Inundation damage to vegetation at selected New England flood control reservoirs. Corps of Eng. Cold Reg. Res. and Eng. Lab. Spec. Rep. 220.

McMenemy, J.R. 1989. West River and Tributaries Atlantic Salmon Fry Stocking Evaluation (job performance report). Vermont Dept. Fish and Game. Project No.: F-12-R-22.

Mills, D. 1989. Ecology and Management of Atlantic Salmon. Chapman and Hall.

Stolte, L.W. 1982. A Strategic Plan for the Restoration of Atlantic Salmon to the Connecticut River Basin. U.S. Fish and Wildlife Service Report.

Stolte, L., and S. Rideout. 1989. Salmon for the future. Atlantic Salmon Jour. Spring. pp 20-21.

Thomas P.A. and M.L. Bourassa. 1986. Cultural Resource Management Study, Townshend Lake, Townshend and Jamaica, Vermont. Rep. Submitted to Sanford Ecological Services, Inc. and Department of the Army, New England Division, Corps of Engineers.

Thomas P.A., P. Dorherty, and E.J. Warren. 1982. Cultural Resource Management Study, Ball Mountain Lake, Jamaica and Londonderry, Vermont. Rep. Submitted to Department of the Army, New England Division, Corps of Engineers.

Thomas, Peter, A. and E. Jan Warren. 1984. Reconnaissance Survey and Site Evaluation for VT-WD-36, Ball Mountain Lake, Jamaica, Vermont. Submitted to: Hydroelectric Development, Inc. Department of Anthropology, University of Vermont Report No. 51, November, 1984.

Westerling, D.L. 1984. Report on Preliminary Conceptual Plans. West Townshend Dam Fish Trapping and Trucking Facility. U.S. Fish and Wildlife Service. Region V. Newton Corner, MA.

U.S. Army Corps of Engineers. 1983. Townshend Lake Water Quality Evaluation. New England Division. Waltham, MA.

U.S. Army Corps of Engineers. 1987. Ball Mountain Lake Water Quality Evaluation. New England Division. Waltham, MA.

VII. COORDINATION

A. Letters Sent

Gordon Beckett (U.S. Fish and Wildlife Service Region V)

February 25, 1991: requested comments on project pursuant to the Fish and Wildlife Coordination Act and Endangered Species Act

November 25, 1991: requested comments on revised plan pursuant to the Fish and Wildlife Coordination Act and Endangered Species Act

Mr. Eric Gilbertson (Vermont Division of Historic Preservation)

February 20, and May 23, 1991: requested comments on the proposed project pursuant to Section 106 of the National Historic Preservation Act

Mr. David Clough (Vermont Division of Water Quality)

February 25, 1991: requested comments on potential water quality impacts associated with the project

Mr. Christopher Fichtel (Vermont Natural Heritage Program)

February 25, 1991: requested comments on potential project impacts on state listed rare, threatened or endangered species

November 25, 1991: requested comments on revised plan regarding impacts on state listed rare, threatened or endangered species

Mr. Steve Wright (Vermont Division of Fish and Wildlife)

February 25, 1991: requested comments on project pursuant to the Fish and Wildlife Coordination Act

November 25, 1991: requested comments on revised plan pursuant to the Fish and Wildlife Coordination Act

Mr. Bernie Toothaker (Appalachian Mountain Club)

February 25, 1991: requested comments on project with particular reference to potential impacts on whitewater recreation opportunities on the West River

B. Letters Received (see Appendix A of Specific Project Report)

Mr. Christopher Fichtel (Vermont Natural Heritage Program)

March 11, 1991: indicated that two species of rare mussels are known to occur in West River

June 12, and June 18, 1991: summarized results of field survey of project area for rare mussels; proposed precautions to protect mussels found downstream of Townshend Lake capture facility

Gordon Beckett (U.S. Fish and Wildlife Service Region V)

March 14, 1991: indicated that no threatened or endangered species were known to occur in the project area; noted that the brook floater, a rare mussel likely to become a candidate species under Endangered Species Act is known to occur in the West River

April 1, 1991: provided comments on proposed project pursuant to Fish and Wildlife Coordination Act; expressed strong support for project and no objections to proposed capture facility design; noted potential project impacts on aquatic and riparian habitat; expressed concerns over operating Ball Mountain Lake under run of the river conditions with no pool

June 18, 1991: summarized results of field survey of project area for rare mussels (although no mussels are present at the capture facility site, a population of brook floater is present ca. on-half mile downstream of the site); noted potential of rapid drawdowns to strand brook floater; recommended monitoring be conducted during test pit sampling

December 10, 1991: noted that the brook floater is now a candidate species for listing under the under Federal Endangered Species Act; indicated interest in monitoring construction impacts on the brook floater population downstream of Townshend Lake

December 19, 1991: provided comments on revised plans for fish capture facility (all comments have been incorporated into the final design); requested more information about water level fluctuations in West River during construction of capture facility

Mr. Eric Gilbertson (Vermont Division for Historic Preservation)

March 22, 1991: indicated that there are no properties of historic, architectural, or archaeological significance in the project area.

Mr. Timothy Van Zandt (Vermont Department of Fish and Wildlife)

April 12, 1991: provided comments on proposed project pursuant to Fish and Wildlife Coordination Act; expressed strong support for project; noted potential project impacts on aquatic habitat.

Mr. Jeff Cueto (Vermont Agency of Natural Resources)

July 23, 1991: provided general comments on reservoir regulation at Ball Mountain Lake. This letter was prepared prior to review of Environmental Assessment; Mr. Cueto had no additional comments on the project after review of the EA (pers. commun., August 22, 1991)

Mr. Ken Cox (Vermont Department of Fish and Wildlife)

August 15 and 22, 1991: provided comments on draft Environmental Assessment (see section VII.E for responses).

December 12, 1991: provided comments on revised plans for fish capture facility (see section VII.E for responses)

C. Personal Communications

Information provided by various individuals during project planning is cited in the text of the EA where appropriate. Principal sources of information concerning Atlantic salmon biology and West River salmon restoration efforts were Mr. Ken Cox (Vermont Department of Fish and Wildlife), Mr. Jay McMenery (Vermont Department of Fish and Wildlife), Mr. Larry Bandolin (U.S. Fish and Wildlife Service, Sunderland, MA Fisheries Assistance Office), Mr. Ted Myers (Connecticut River Coordinator, Atlantic Salmon Restoration Team), Mr. Ben Rizzo (U.S. Fish and Wildlife Service, Newton Corner, MA), and Mr. Bob Orciari (Connecticut Department of Marine Fisheries). Mr. Chris Fichtel and Ms. Susi von Oettingen were contacted concerning status of rare, threatened or endangered freshwater mussels in the West River and participated in a site visit with Corps personnel. Ms. Laurie Thorpe of the Corps Ball Mountain Lake office provided information concerning wildlife and recreational resources, and West River water temperature. Mr. Dan Darrell (West River Riverwatch Program, Townshend VT), and the U.S.G.S also provided information about West River water temperature.

D. Technical Working Group Meetings

Early in the study a Technical Working Group consisting of representatives of state and federal resource agencies, the Corps, and the interested public was formed (a list of participants is provided in the main Specific Project Report). Meetings were held on February 22, 1990, March 26, 1990, and November 14, 1990. Several additional meeting were held with Mr. Ben Rizzo of the U.S. Fish and Wildlife Service to discuss the design of the capture facility.

E. Responses to Comments on Draft Environmental Assessment

August 15, 1991 letter from Mr. Ken Cox (VT Dept. Fish and Wildlife)

Comments 1 - 19 and 21: Comment noted and/or incorporated into final Environmental Assessment.

Comment 20: We continue to hold that reintroduction of a few breeding pairs of osprey at Ball Mountain or Townshend Lake would have no discernible impact on the West River salmon restoration program. At most, breeding pairs are likely to take several smolts per day during the month long smolt outmigration period as smolts pass through Townshend Lake and Ball Mountain Lake. Little predation by osprey is likely to occur during the rest of the year when parr or smolts are predominately in shallow, turbulent, riverine habitat.

August 22, 1991 letter from Mr. Ken Cox (VT Dept. Fish and Wildlife)

Comments 1,3.b.,5-9,11-12: Comment noted and/or incorporated into final Environmental Assessment.

Comment 2: The Corps will work with the Vermont Department of Fish and Wildlife to develop a SOP for operation of the capture facility and upstream transport of adult salmon. The Corps should not be financially responsible for added costs associated with transport of salmon above non-Corps dams.

Comment 3.a.: 1991 smolt release studies were conducted under moderate to low flow conditions (ca. 300 cfs). A copy of the 1991 FWS report has been forwarded to the Vermont Dept. of Fish and Wildlife.

Comment 3.c.: Although we agree that maintaining run of the river conditions at Ball Mountain Lake would insure smolt passage with minimum delay or mortality, U.S. FWS studies to date have found that maintaining a 25-foot pool has no biologically significant adverse impact on outmigrating smolts under moderate to high flows. Advantages and disadvantages of maintaining year round run of the river conditions at Ball Mountain Lake are summarized below:

Advantages:

o Elimination of the conservation pool would provide an additional 1-2 miles of riverine habitat suitable for Atlantic salmon smolts (the value of this habitat would be limited, however, because the river would be frequently flooded during normal reservoir operations).

o Elimination of the conservation pool would expose about 100-125 acres of mudflat. A portion of this area would be quickly colonized and stabilized by riparian vegetation, and provide wildlife habitat. The remaining area would probably not be vegetated to any significant extent due to frequent inundation during normal reservoir operations.

o Vegetation would partially stabilize mudflats and reduce sediment erosion during winter months (under current operating protocol unvegetated mudflats are exposed, depending on snow cover, from late fall through spring).

o Reservoir operation would be simplified.

Disadvantages:

o A large quantity of sediment deposited in the old West River channel within the reservoir would be eroded and washed downstream. Although it is presently impossible to determine the extent of erosion that would occur, it is likely that substantial erosion would occur for at least several years after elimination of the conservation pool. Also, retention of sediments originating from eroding embankments upstream of Ball Mountain Lake (primarily along the Winhall River) would no longer occur. Sedimentation downstream of the dam would severely impact existing fish and aquatic invertebrate communities. Siltation in Townshend Lake would increase.

o The fishery provided by the 65-foot conservation pool would be lost (this loss is considered minor by the Vermont Dept. of Fish and Wildlife and could be mitigated by stocking the restored West River channel within the reservoir).

o The quality of the cold water fishery maintained downstream of Ball Mountain Lake by releases from the reservoir during summer months would decline (this impact could be partially mitigated for by increased stocking of brown trout downstream of the dam).

o The reservoir could no longer be used to provide low flow augmentation during abnormally dry years.

o Elimination of the conservation pool would preclude making spring, and possibly fall, releases for whitewater recreation (storing water for spring releases would be unacceptable because vegetation would be inundated during the beginning of the growing season).

o Opportunities to boat on the reservoir would be lost (currently little boating occurs due to poor access).

o An adverse aesthetic impact would occur due to exposure of unsightly eroding embankments, some of which would probably not become revegetated due to frequent inundation.

o Reservoir gates could freeze unless a 25-foot pool was maintained over winter.

Comment 4: This statement was removed from the final EA. Flows exceeding 2000 CFS during late May and June, however, would be rare, and probably occur less than 5 percent of the time. The Corps and Vermont Department of Fish and Wildlife will develop an SOP for operation of the barrier.

Comment 10: No additional data on impacts of Ball Mountain Lake discharge on West River Water temperature downstream of the project is available.

Other individuals requesting copies of the draft EA (Mr. Jeff Cueto, Vermont, Depart. of Environmental Conservation, Mr. Jonathan Kurland, NMFS, Mr. Bernie Toothaker, Appalachian Mountain Club Dam Release Coordinator, and Mr. Joe Marrone, Concord, NH) had no comments.

F. Responses to Comments on Revised Capture Facility Design

December 12, 1991 letter from Mr. Ken Cox (VT Dept. Fish and Wild.)

Comment A1: Maintenance of the facility is a valid concern. The well underneath the floor grate of the holding/brail pool will serve to prevent small debris from building up in the actual salmon holding area. Large debris will be removed by a trash rack at the entrance to the trap.

Comment A2: Provisions will be made to allow closure of the V-notch entrance to the brailing/holding pool with a grate.

Comment A3: At present any overlap between smolt and adult migratory periods is assumed to be minimal (installation of the barrier for adults will occur ca. May 15, after the likely peak smolt outmigration period). There is however, some uncertainty as to the timing of smolt outmigration in the West River. Also, the Vermont Dept. Fish and Wildlife may wish to have the barrier installed before May 15 to aid in counting outmigrating smolts.

Design of the barrier was modified to allow for installation of a smolt trap. It was not deemed necessary to vary bar spacings in the barrier.

Comment A4: Because the barrier will be in place at flows up to ca. 5,000 cfs, there will be little or no opportunity for salmon to enter into the plunge pool.

Comment B1: All possible measures will be taken to minimize inundation of riparian vegetation during construction. For reasons discussed elsewhere, the 65-foot Ball Mountain Lake conservation pool will be maintained.

Comment B2: Construction will occur in the dry.

Comment B3: Minimum flows suggested by the Vermont DFW have been incorporated into the water control plan.

Comment B4: Concur.

Comment B5: Review of water control plans will be part of the water quality certification process.

December 10, 1991 letter from Mr. Gordon Beckett (US FWS)

NED will inform the US FWS and Vermont Natural Heritage Program of the construction schedule and will assist in monitoring of rare mussel populations situated downstream of Townshend Lake.

The need to use Ball Mountain and Townshend Lakes to regulate West Rive flow will depend on conditions during construction. During a dry year the water control plan should have little impact on normal West River flow. During an abnormally wet year some additional variably in West River flow will result from the control plan.

December 19, 1991 letter from Mr. Gordon Beckett (US FWS) with attached Memo from Mr. Ben Rizzo (US FWS).

All design changes recommended in the Memo by Mr. Rizzo have been incorporated into final plans.

VIII. COMPLIANCE WITH FEDERAL ENVIRONMENTAL STATUTES, EXECUTIVE MEMORANDUM, AND EXECUTIVE ORDERS

Federal Statutes

1. Preservation of Historic and Archaeological Data Act of 1974, as amended, 16 U.S.C. 469 et seq.

Compliance: Consultation with the State Historic Preservation Office concerning mitigation of historic and/or archaeological resources signifies compliance.

2. Clean Air Act, as amended, 42 U.S.C. 7401 et seq.

Compliance: Public notice of the availability of this report to the Environmental Protection Agency signifies compliance pursuant to Sections 176c and 309 of the Clean Air Act

3. Clean Water Act of 1977 (Federal Water Pollution Control Act Amendments of 1972) 33 U.S.C. 1251 et seq.

Compliance: A Section 404(b)(1) Evaluation and Compliance Review have been incorporated into this report. An application will be filed for State Water Quality Certification pursuant to Section 401 of the Clean Water Act.

4. Coastal Zone Management Act of 1972, as amended, 16 U.S.C. 1431 et seq.

Compliance: Not applicable.

5. Endangered Species Act of 1973, as amended, 16 U.S.C. 1531 et seq.

Compliance: Coordination with the U.S. Fish and Wildlife Service (see letter dated 14 March and 10 December, 1991) has yielded no formal consultation requirements pursuant to Section 7 of the Endangered Species Act.

6. Estuarine Areas Act, 16 U.S.C. 1221 et seq.

Compliance: Not applicable.

7. Federal Water Project Recreation Act, as amended, 16 U.S.C. 4601-12 et seq.

Compliance: Public notice of the Availability of this report to the National Park Service (NPS) and the Office of Statewide Planning relative to the Federal and State comprehensive outdoor recreation plans signifies compliance with this Act.

8. Fish and Wildlife Coordination Act, as amended, 16 U.S.C. 661 et seq.

Compliance: Coordination with the U.S. FWS and State of Vermont resource agencies signifies compliance with the Fish and Wildlife Coordination Act.

9. Land and Water Conservation Fund Act of 1965, as amended, 16 U.S.C. 4601-4 et seq.

Compliance: Public notice of the availability of this report to the National Park Service (NPS) and the Office of Statewide Planning relative to the Federal and State comprehensive outdoor recreation plans signifies compliance with this Act.

10. Marine Protection, Research, and Sanctuaries Act of 1972, as amended, 33 U.S.C. 1401 et seq.

Compliance: Not Applicable.

11. National Historic Preservation Act of 1966, as amended, 16 U.S.C. 470 et seq.

Compliance: Coordination with the State Historic Preservation Office determined that no historic or archaeological resources would be affected by the proposed project (see March 22, 1991 letter from Mr. Eric Gilbertson, .

12. National Environmental Policy Act of 1969, as amended, 42 U.S.C. 4321 et seq.

Compliance: Preparation of this report signifies partial compliance with NEPA. Full compliance shall be noted at the time the Finding of No Significant Impact is issued.

13. Rivers and Harbors Act of 1899, as amended, 33 U.S.C. 401 et seq.

Compliance: No requirements for Corps projects or programs authorized by Congress. The proposed shoreline stabilization project is pursuant to the Congressionally-approved continuing authority program: Section 14 of the 1946 Flood Control Act.

14. Watershed Protection and Flood Prevention Act, as amended, 16 U.S.C. 1001 et seq.

Compliance: Not applicable.

15. Wild and Scenic Rivers Act, as amended, 16 U.S.C. 1271 et seq.

Compliance: Not Applicable.

Executive Orders

1. Executive Order 11988, Floodplain Management, 24 May 1977 amended by Executive Order 12148, 20 July 1979.

Compliance: Not Applicable.

2. Executive Order 11990, Protection of Wetlands, 24 May 1977.

Compliance: Circulation of this report for public review fulfills the requirements of Executive Order 11990, Section 2(b).

3. Executive Order 12114, Environmental Effects Abroad of Major Federal Actions, 4 January 1979.

Compliance: Not Applicable.

Executive Memorandum

1. Analysis of Impacts on Prime or Unique Agricultural Lands in Implementing NEPA, 11 August 1980.

Compliance: Not Applicable.

FINDING OF NO SIGNIFICANT IMPACT (FONSI)

FINDING OF NO SIGNIFICANT IMPACT (FONSI)

After careful consideration of the information in this Environmental Assessment, it is my conclusion that the proposed structural and operational modifications at Townshend Lake and Ball Mountain Lake to enhance Atlantic Salmon passage are in the public interest, and would have no significant impact on the environment.

In my evaluation, this Environmental Assessment has been prepared in accordance with the National Environmental Policy Act of 1969. The determination that an Environmental Impact Statement is not required is based on the information contained in the Environmental Assessment, including the following considerations.

1. The proposed plan would have no significant impact on any rare, threatened or endangered species.

2. It is unlikely that the proposed project would have an adverse affect upon any structure or site of historic, architectural or archaeological significance.

3. No significant adverse impacts on water quality will occur as a result of the project.

4. The project would have no significant adverse impact on aquatic life in the West River.

5. Several measures would be implemented to minimize potential adverse environmental consequences of the project (see Section V of the Environmental Assessment).

In my evaluation, the Environmental Assessment has been prepared in accordance with the National Environmental Policy Act of 1969. Based on my evaluation of the environmental effects as presented in the Environmental Assessment, I have determined that this project is not a major federal action significantly affecting the quality of the human environment. It is therefore exempt from requirements to prepare an Environmental Impact Statement.

13 Dec 92
Date

Philip R. Harris
Philip R. Harris,
Colonel, Corps of Engineers
Division Engineer

SECTION 404(b)(1) EVALUATION

NEW ENGLAND DIVISION
U.S. ARMY CORPS OF ENGINEERS, WALTHAM, MA
SECTION 404(b)(1) EVALUATION

PROJECT: Connecticut River Fish Passage Study, West River Vermont

PROJECT MANAGER: Mr. Richard Heidebrecht EXT. 617-647-8513

FORM COMPLETED BY: Michael Penko EXT. 617-647-8139

PROJECT DESCRIPTION:

The proposed action involves construction of a facility to capture adult Atlantic salmon in the West River, Vermont. The facility is intended to enhance ongoing state and Federal efforts to restore Atlantic salmon (Salmo salar) in the river. Under present conditions, dams at two Corps of Engineers flood control projects (Townshend Lake and Ball Mountain Lake) block migration of Atlantic salmon to the majority of potential spawning habitat in the West River basin.

The proposed facility consists of a fish barrier built across the river and an instream trap (see Plates 8 thru 11 in the Specific Project Report). Salmon captured in the trap will be transferred to a holding tank and trucked upstream of Ball Mountain Lake and/or Townshend Lake. The trap will be operated between mid May and November. Based on projected returns of adult salmon to the river, it is anticipated that at least 550 salmon will be trapped at the facility each year.

Construction the the facility will require excavation of several thousand cubic yards of coarse grained material and rock from the West River. The material will be disposed of at an existing upland disposal site. Construction of the facility will require placement ordinary fill (for cofferdams), concrete, sheet piling, stone protection into the West River.

Construction is currently scheduled to occur from July, 1992 through February, 1993. In-stream work will be completed by the end of November, 1992.

NEW ENGLAND DIVISION
U.S. ARMY CORPS OF ENGINEERS, WALTHAM, MA

PROJECT: Connecticut River Fish Passage Investigation, West River, Vermont

Evaluation of Section 404(b)(1) Guidelines

1. Review of Compliance (Section 230.10(a)-(d)).

a. The discharge represents the least environmentally damaging practicable alternative and if in a special aquatic site, the activity associated with the discharge must have direct access or proximity to, or be located in the aquatic ecosystem to fulfill its basic purpose;

| X | | YES | | NO

b. The activity does not appear to: 1) violate applicable state water quality standards or effluent standards prohibited under Section 307 of the CWA; 2) jeopardize the existence of Federally listed threatened and endangered species or their critical habitat; and 3) violate requirements of any Federally designated marine sanctuary check responses from resource and water quality certifying agencies);

| X | | YES | | NO

c. The activity will not cause or contribute to significant degradation of waters of the U.S. including adverse effects on human health, life stages of organisms dependent on the aquatic ecosystem, ecosystem diversity, productivity and stability, and recreational, aesthetic, and economic values;

| X | | YES | | NO

d. Appropriate and practicable steps have been taken to minimize potential adverse impacts of the discharge on the aquatic ecosystem

| X | | YES | | NO

2. <u>Technical Evaluation Factors (Subparts C-F).</u>

a. Potential Impacts on Physical and Chemical Characteristics of the Aquatic Ecosystem (Subpart C).

	N/A	Not Significant	Significant
1) Substrate.		X	
2) Suspended particulates/turbidity.		X	
3) Water.		X	
4) Current patterns and water circulation.		X	
5) Normal water fluctuations.	X		
6) Salinity gradients.	X		

b. Potential Impacts on Biological Characteristics of the Aquatic Ecosystem (Subpart D).

	N/A	Not Significant	Significant
1) Threatened and endangered species.	X		
2) Fish, crustaceans, mollusks and other aquatic organisms in the food web.		X	
3) Other wildlife.		X	

c. Potential Impacts on Special Aquatic Sites (Subpart E).

	N/A	Not Significant	Significant
1) Sanctuaries and refuges.	X		
2) Wetlands.		X	
3) Mud flats.		X	
4) Vegetated shallows.	X		
5) Coral reefs.	X		
6) Riffle and pool complexes.	X		

d. Potential Effects on Human Use Characteristics (Subpart F).

	N/A	Not Significant	Significant
1) Municipal and private water supplies.	X		
2) Recreational and Commercial fisheries.		X	
3) Water-related recreation.		X	
4) Aesthetics.		X	
5) Parks, national and historic monuments, national seashores, wilderness areas, research sites, and similar preserves.	X		

3. <u>Evaluation and Testing (Subpart G).</u>

a. The following information has been considered in evaluating the biological availability of possible contaminants in dredged or fill material. (Check only those appropriate.)

1) Physical characteristics.......................... [X]
2) Hydrography in relation to known or anticipated sources of contaminants.......................... [X]
3) Results from previous testing of the material or similar material in the vicinity of the project.......................... [ ]
4) Known, significant sources of persistent pesticides from land runoff or percolation.......................... [ ]
5) Spill records for petroleum products or designated hazardous substances (Section 311 of CWA).................. [ ]
6) Public records of significant introduction of contaminants from industries, municipalities, or other sources..... [ ]
7) Known existence of substantial material deposits of substances which could be released in harmful quantities to the aquatic environment by man-induced discharge activities.............. [ ]
8) Other sources (specify).......................... [X]

<u>List appropriate references</u>.

Environmental Assessment completed for this project.

b. An evaluation of the appropriate information in 3a above indicates that there is reason to believe the proposed dredge or fill material is not a carrier of contaminants, or that levels of contaminants are substantively similar at extraction and disposal sites and not likely to require constraints. The material meets the testing exclusion criteria. [X] YES [ ] NO

4. Disposal Site Delineation (Section 230.11(f)).

a. The following factors, as appropriate, have been considered in evaluating the disposal site.

1) Depth of water at disposal site.................. [X]
2) Current velocity, direction, and variability at disposal site.......................... [ ]
3) Degree of turbulence............................. [ ]
4) Water column stratification...................... [ ]
5) Discharge vessel speed and direction.. [ ]
6) Rate of discharge................................ [ ]
7) Dredged material characteristics (constituents, amount, and type of material, settling velocities)............... [X]
8) Number of discharges per unit of time... [ ]
9) Other factors affecting rates and patterns of mixing (specify)..................... [ ]

List appropriate references. See Environmental Assessment

b. An evaluation of the appropriate factors in 4a above indicates that the disposal site and/or size of mixing zone are acceptable....... [X] YES [ ] NO

5. Actions To Minimize Adverse Effects (Subpart H).

All appropriate and practicable steps have been taken, through application of recommendation of Section 230.70-230.77 to ensure minimal adverse effects of the proposed discharge................................ [X] YES [ ] NO

List actions taken.

See Environmental Assessment prepared for this project.

6. Factual Determination (Section 230.11).

A review of appropriate information as identified in items 2 - 5 above indicates that there is minimal potential for short or long term environmental effects of the proposed discharge as related to:

a. Physical substrate (review sections 2a, 3, 4, and 5 above). YES [X] NO [ ]

b. Water circulation, fluctuation and salinity (review sections 2a, 3, 4, and 5). YES [X] NO [ ]

c. Suspended particulates/turbidity (review sections 2a, 3, 4, and 5). YES [X] NO [ ]

d. Contaminant availability (review sections 2a, 3, and 4). YES [X] NO [ ]

e. Aquatic ecosystem structure, function and organisms(review sections 2b and c, 3, and 5) YES [X] NO [ ]

f. Proposed disposal site (review sections 2, 4, and 5). YES [X] NO [ ]

g. Cumulative effects on the aquatic ecosystem. YES [X] NO [ ]

h. Secondary effects on the aquatic ecosystem. YES [X] NO [ ]

7. Findings of Compliance or non-compliance.

a. The proposed disposal site for discharge of dredged or fill material complies with the Section 404(b)(1) guidelines.. [X]

13 Feb 92
DATE

Philip R. Harris
Philip R. Harris
Colonel, Corps of Engineers
Division Engineer

APPENDIX A

PERTINENT CORRESPONDENCE

State of Vermont

Department of Fish and Wildlife
Department of Forests, Parks and Recreation
Department of Environmental Conservation
State Geologist
Natural Resources Conservation Council

AGENCY OF NATURAL RESOURCES
103 South Main Street, 10 South
Waterbury, Vermont 05676
802-244-7331
DEPARTMENT OF FISH AND WILDLIFE

January 24, 1992

Col. Philip R. Harris
Division of Engineers
Department of the Army
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254-9149

Re: Local Cooperation Agreement for Fish Passage Facilities at West River, Vermont

Dear Mr. Harris:

The Vermont Department of Fish and Wildlife, as party to a compact approved by Congress (P.L. 98-138, 97 Stat. 866) which formed the Conn. River Atlantic Salmon Commission supports the construction of the fish passage facilities at the Townshend and Bald Mountain Dams on the West River in Vermont. These facilities are necessary for the restoration of atlantic salmon in the Connecticut River basin, and thus were recommended by, and the the full support of the Salmon Commission. The four basin States (VT, NH, MA, CT) plus two Federal agencies (USF&WS and NMFS) are parties to the Commission.

These projects are all on Federal land, so there are no additional lands, easements, right-of-ways, or relocations necessary for construction and operation of the fish passage facilities.

In that all the construction and operation activities will be taking place on Federal property and the passage facilities will also be Federal property, it seems unlikely that the State would hold the Federal Government liable for damages due to the construction and operation of the fish passage facilities to their own (Federal) property.

In summary, it is our intent to fully support these projects; however, we do have some concerns with the draft agreement that was forwarded for review. We feel confident that these concerns can be worked out, and would hope in the interim that the projects can move forward.

Sincerely,

J. Timothy Van Zandt
Commissioner

tvz:bo

cc: Richard Heidebrecht
Bob Paquin
Ken Cox
Frederick Coleman

United States Department of the Interior

FISH AND WILDLIFE SERVICE
400 RALPH PILL MARKETPLACE
22 BRIDGE STREET
CONCORD, NEW HAMPSHIRE 03301-4901

REF: Townshend Dam

December 19, 1991

Mr. Joseph L. Ignazio, Director
Planning Directorate
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254-9149

ATTN: Impact Analysis Division

Dear Mr. Ignazio:

This letter is in response to your letter dated November 25, 1991, requesting our comments on the revised functional design plans for an Atlantic salmon capture facility at Townshend Lake on the West River in Vermont.

Our Regional Engineering Office (REO) has reviewed the plans and generally accepts the design of the scaled down passage facility, with minor modifications. Comments and design sketches from our REO are attached.

Regarding the impacts of the proposed construction activities on downstream flows, we have some questions regarding low flow releases and the fluctuation of flows below Townshend Dam on resident fish inhabiting the affected reach. More detailed information regarding the flow range and the frequency of flow fluctuations is needed. Similar information has been requested in our letter dated December 10, 1991 regarding the swollen brook floater (*Alasmidota varicosa*). Fisheries concerns should be addressed coincident with the consultation on mussels requested in that letter.

Thank you for this opportunity to comment. Please address any questions or comments regarding the design drawings to Mr. Ben Rizzo of the REO and any other questions or comments to Mr. John Warner of this office at (603) 225-1411.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor
New England Field Offices

cc: RO/EN - B. Rizzo
Connecticut River Coordinator - T. Meyers
Conte NF&W Refuge - L. Bandolin
VDFW, Springfield - K. Cox
Terry Martin, OEA
RO/FWE Reading File
Bob Paquin, Sen Leahy's Office
Brian Keefe, Sen. Jeffords' Office
2 S. Main St., Rutland, VT 05701-0397
FWE:JWarner:12-19-91:834-4411

State of Vermont

AGENCY OF NATURAL RESOURCES

DEPARTMENT OF FISH AND WILDLIFE

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(802) 878-1564

☐ 324 N. Main Street
Barre, VT 05641
(802) 479-3241

■ RR #1, Box 33
N. Springfield, VT 05150
(802) 886-2215

☐ 180 Portland Street
St. Johnsbury, VT 05819
(802) 748-8787

☐ RFD 1, Pittsford Academy
Pittsford, VT 05763
(802) 483-2172

Department of Fish and Wildlife
Department of Forests, Parks, and Recreation
Department of Environmental Conservation
State Geologist
Natural Resources Conservation Council

December 12, 1991

Mr. Michael Penko
Impact Analysis Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254-9149

Dear Mike:

This letter is in response to your request for comments on the latest revised plans for the Townshend Dam Atlantic salmon capture facility.

A <u>Fish trap design features</u>:

1. The concrete pad supporting the fish trap is recessed 3 feet lower (El. 450.0) than the pad immediately upstream (El. 453.0) and downstream (El. 452.0) in order to accommodate the hopper bay and holding/brail pool. I understand this three foot deep well is needed to allow the facility to operate under the low river flow conditions that will arise during the salmon migration season. I am concerned that the well will act as a settling basin for gravel, cobbles and sediments displaced from above during any high flow events occurring during the migration period. So as to minimize mechanical problems that could arise and interfere with hopper and floor brail operation and result in facility down time when the salmon are actively moving upstream, it is important that full attention be given to designs and procedures to assure the capture facility is kept in good working condition.

2. While the plans do not indicate provisions for slide gates located between the hopper bay-holding/brail pool and V-notch-holding/brail pool interfaces. Provisions for such gates will permit greater control over the movements of salmon once in the trapping facility.

3. The width of the opening between the barrier fence bars (1 3/4 inches) and anticipated low flow velocities may not be a problem for outmigrating salmon smolts, but this may have to be evaluated once the facility becomes operational. The barrier fence may function as a guidance structure directing smolts to its

most downstream location (north end). If so, this end of the barrier fence should be designed to facilitate smolt passage but should not be at the expense of the fence's role as an adult fish barrier. Wider bar spacing in the most downstream fence panel may accomplish this. Also, consideration should be given at this time to designing the downstream end of the fence so it can be easily retrofitted in the future with another smolt egress or counting/trapping facility. I suggest the downstream panel be designed as two 5 foot wide panels rather than one 10 feet wide. These panels should be mounted in such a way to allow easy removal without the need for re-engineering and major structural modification. Perhaps the most downstream 5 foot panel could be designed to swing open downstream and latch to the north wing wall. Such a gate setup should be recessed into the wall when in the open position.

4. As a last item on the barrier fence, some thought needs to be given to how any salmon getting access to the plunge pool below Townshend Dam outlet will be recovered. It is quite possible that some salmon will get above the barrier fence especially if the fence is lowered in response to a high flow event (>1500 cfs). Has an analysis been done on the frequency flows greater than 1500 cfs occurring at this site? Has any thought been given to using the reservoirs to manage high flows to keep discharge below 1500 cfs during the salmon migration seasons?

B <u>Project construction and water control</u>:

1. If the reservoirs are to be used to store water during construction in order to reduce flows to manageable levels below Townshend Dam, pooling to the extent of inundating riparian vegetation should be avoided. From the onset of project planning, this department has stressed the importance of re-establishing riparian vegetation around Ball Mountain Reservoir, particularly if a 25 foot pool is established to facilitate smolt outmigration. Existing and reestablished vegetation on barren impoundment slopes will reduce erosion, siltation and improve project aesthetics in the long run.

2. This department recommends coffer dams or sheet piling barriers be used to allow construction to occur in the "dry".

3. Minimum flows below both Ball Mountain and Townshend Dams should be maintained at 90 and 139 cfs, respectively, or natural instantaneous inflows, whichever is less. These values are based on this agency's minimum flow recommendations to hydroelectric power developers, who have shown interest in developing these projects in the past.

4. Excessive discharge from both dams, especially if not released gradually, will be detrimental to the aquatic community at large and is not a concern exclusively limited to the freshwater mussel beds below Townshend Dam.

5. This agency will want to review any detailed proposals for managing river flows and water quality protection connected to project construction.

Lastly, I want to express this department's concern regarding having this project completed under the dollar ceiling authorized by Congress. Considerable time and money has been spent to date on developing conceptual design proposals and yet finalized plans are not yet in sight, even though we are looking at construction to occur in 1992. It is critical for continued congressional support and salmon restoration in the West River basin that an operational capture facility be in place by 1993.

If you have any questions or responses to questions presented above, please call me.

Sincerely,

Ken

Kenneth M. Cox
District Fisheries Biologist

KMC:mmc

cc: A. Incerpi
T. Meyers
B. Rizzo

United States Department of the Interior

FISH AND WILDLIFE SERVICE
400 RALPH PILL MARKETPLACE
22 BRIDGE STREET
CONCORD, NEW HAMPSHIRE 03301-4901

December 10, 1991

Joseph Ignazio, Chief
Planning Directorate
U.S. Army Corps of Engineers
424 Trapelo Rd.
Waltham, MA 02254-9149

Dear Mr. Ignazio:

This responds to your letter dated November 25, 1991 requesting comments on the revised plans for the Townshend Lake Atlantic Salmon capture facility on the West River in Vermont. Since our last correspondence of February 25, 1991, no species have been Federally listed, nor have new occurrences of Federally listed threatened or endangered species within the proposed project area been found. In our letter of June 18, 1991, we identified the presence of a proposed candidate (Category 2) species, the swollen brook floater, *Alasmidonta varicosa*. This species has now officially been added to the Animal Notice of Review and is considered to be a Federal candidate for listing.

It appears that the construction of the new proposed facility should not adversely impact *Alasmidonta varicosa*. However, we would like to continue to coordinate with you about changing water levels during construction. Therefore, please notify us when the construction and water level manipulation begins, so that we may monitor the mussels before, during and after construction activities. Recent status surveys throughout the mussel's range indicate that it is declining and we need to be assured that the mussel will not be impacted by the changing water levels.

Your letter stated that the flow in the West River downstream of the dams would be more variable than that under normal operating conditions. How far downstream are these fluctuations expected to occur, and how variable? Because so little is known about the impacts of water level fluctuations to invertebrates and in particular, mussels, we would like to continue to work with you, so that adverse impacts to *Alasmidonta varicosa* be avoided. As in all New England mussel species, *Alasmidonta varicosa* needs a host fish in order to complete its reproductive cycle. Though we do not know exactly which fish is host to the glochidia of this species, changes in water level fluctuations should consider fisheries.

Thank you for your cooperation. Please contact Susi von Oettingen of this office at (603) 225-1411 if you have any questions about our comments or if we can be of further assistance.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor
New England Field Offices

UNITED STATES GOVERNMENT

memorandum

U.S. FISH AND WILDLIFE SERVICE

ONE GATEWAY CENTER
SUITE 700
NEWTON CORNER, MASSACHUSETTS 02158

TO: John Warner (ES) Concord, NH

FROM: Ben Rizzo, Hydraulic Engineer B. Rizzo

DATE: December 5, 1991

SUBJECT: Revised Plans for Atlantic Salmon Trapping Facility at Townshend Dam on West River - Vermont

Reference is made to the November 25, 1991 letter from the Corps of Engineers (copy attached) requesting Service comments on revised plans and construction procedures for the proposed salmon trapping facility to be constructed by the Corps below the Townshend Dam in 1992.

The revised plans were presented and briefly discussed at a November 12, 1991 consultation meeting at our Regional Office attended by myself and Dick Heidebrecht and Mike Penko from the Corps. The revised plans include two large drawings (IRS-14-Sheet #1) dated November 1991 and two 11" x 17" sketches entitled "Fish Trapping Structures" dated November 7, 1991. In addition a large topographic survey plan dated October 30, 1991 was also provided.

We have also participated in five project design meetings with the Corps since May 1991.

The plans have been revised (with our consent) to delete the Denil fishway, fish holding pool and associated 20 cfs attraction water pumping system included in previous designs. In addition the in-stream concrete piers and walkway for the angled fish barrier fence/rack have been deleted to keep project costs within available funding.

The fish trap now proposed is located <u>in-stream</u> at the upstream end of the angled fish barrier rack on the right bank of the river, in the same general area as the previous design. The angled fish barrier rack (1 1/2" clear bar spacing) can also be utilized with some modifications to include salmon smolt sampling devices. Budget constraints do not allow this feature to be included in present plans.

<u>Comments</u>:

1. <u>General Arrangement</u>

- We concur with the revised layout of the fish trap and fish barrier and recommend the Corps proceed with final design plans and specifications to facilitate construction in 1992.

- The fish trapping facility is to be operational during the salmon migration period at flows up to 1,500 cfs (stage = 457.7'). At flows above 1,500 cfs the Corps may lower the rack to prevent damage, the barrier rack operational details have not been defined.

2. <u>Fish Trap</u>

- We suggest modifications to the interior of the fish trap as indicated on the attached two sketches. The suggested layout is similar to the salmon trapping facility at the Lawrence hydro-project on the Merrimack River in Lawrence, Massachusetts which the Corps staff inspected on May 31, 1991.

- The vertical racks and "V" trap can be constructed with aluminum grating (1" x 4" openings) or preferably with 3/4" to 1" diameter PVC or aluminum rods/tubes with a 1 1/2" maximum clear spacing between members.

- We recommend all vertical grating and racks be readily removable by inserting them in channel guides.

- Operating water level ranges should be indicated on the plans.

Attachments

cc: Ted Meyers (FWS)
Ken Cox (VT F&W)

NED FORM 223
27 Sept 49

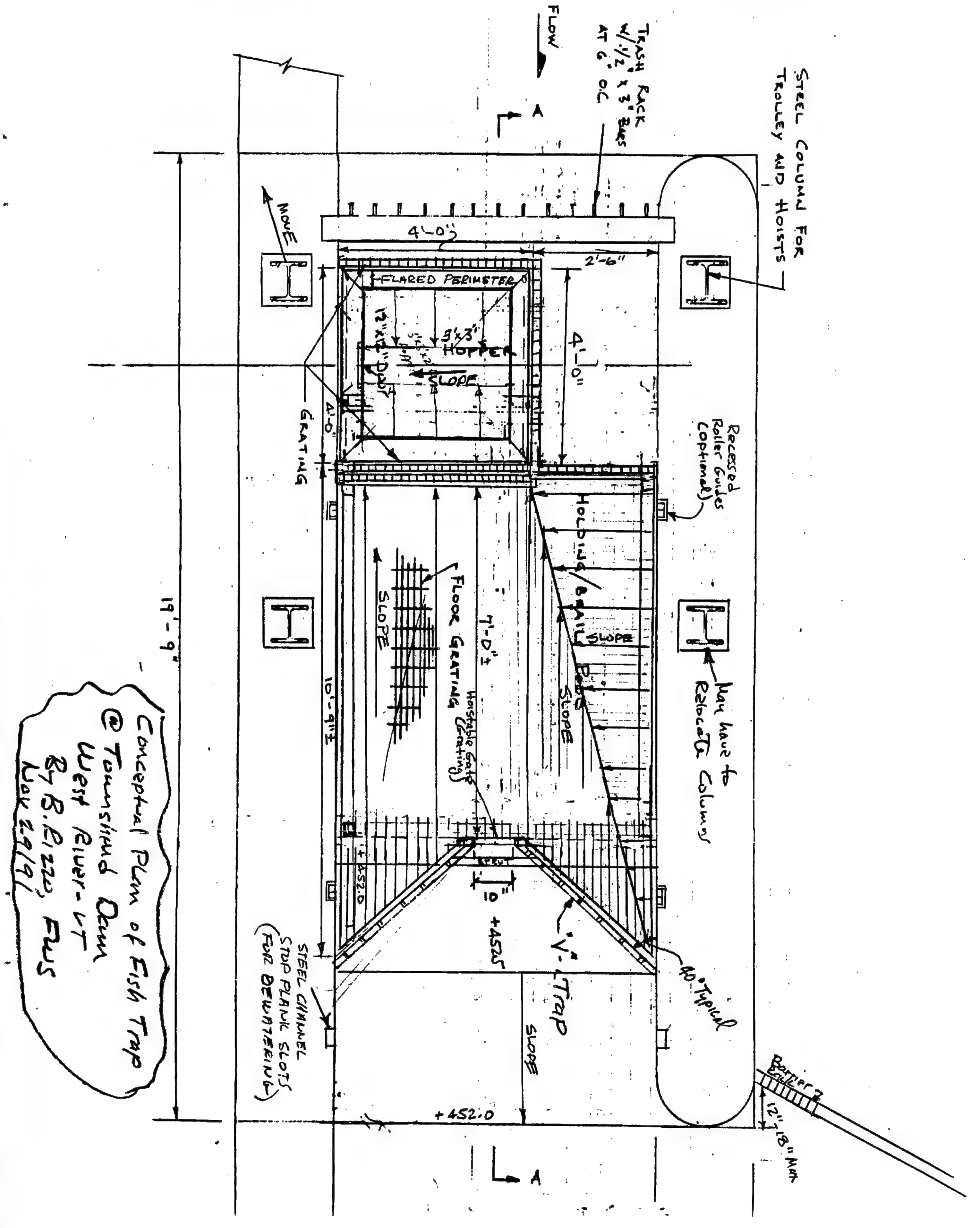
NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U.S. ARMY

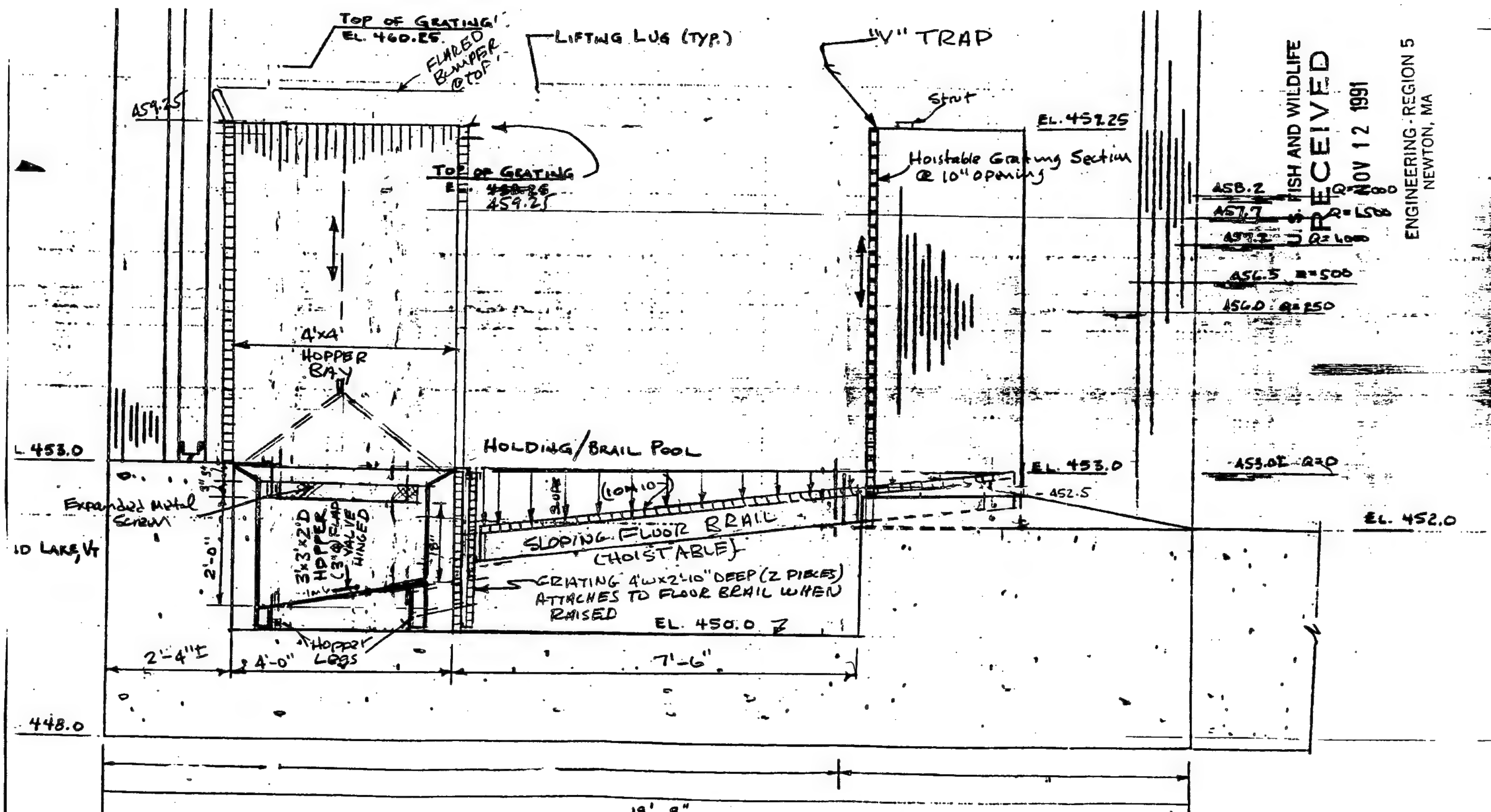
PAGE ____

SUBJECT: Fish Passage Facility - Townshend Lake, Vt

COMPUTATION: Fish Trapping Structure

COMPUTED BY: ________ CHECKED BY: ________ DATE: ________





TOP OF GRATING
EL. 460.25
FLARED BUMPER @ TOP
LIFTING LUG (TYP.)
"V" TRAP
Strut
EL. 457.25
Hoistable Grating Section @ 10" opening
459.25
TOP OF GRATING
EL. 459.25
4'x4' HOPPER BAY
HOLDING/BRAIL POOL
EL. 453.0
452.5
EL. 452.0
L. 453.0
Expanded Metal Screen
3'x3'x2'D HOPPER (3" FLAP VALVE HINGED
SLOPING FLOOR BRAIL (HOISTABLE)
GRATING 4'W x 2'-10" DEEP (2 PIECES) ATTACHES TO FLOOR BRAIL WHEN RAISED
EL. 450.0
Hopper Legs
2'-0"
2'-4"
4'-0"
7'-6"
448.0
19'-9"
458.2 Q=2000
457.7 Q=1500
456.5 Q=500
456.0 Q=250
453.0 Q=0

SECTION A-A

State of Vermont
AGENCY OF NATURAL RESOURCES

DEPARTMENT OF FISH AND WILDLIFE

Department of Fish and Wildlife
Department of Forests, Parks, and Recreation
Department of Water Resources & Environmental Engineering
State Geologist
Natural Resources Conservation Council

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Pittsford, VT 05763
(802) 483 2172

☐ 324 N. Main Street
Barre, VT 05641
(802) 479-3242

☐ 180 Portland Street
St. Johnsbury, VT 05819
(802) 748-8787

MEMORANDUM

TO: Michael Penko, Biologist, Corps of Engineers

FROM: Kenneth Cox, District Fisheries Biologist KMC

DATE: 22 August 1991

SUBJECT: Additional Comments on Townshend and Ball Mountain Fish Passage Draft EA

Please accept an apology from me for this late submission of additional comments on the draft EA. Jay McMenemy also reviewed the draft report and brings attention to a number of important technical corrections as well as adds clarification to statements presented in the EA. While I realize you are in the closing stages of revising the draft toward a final report, the following items, if at all possible, should be included in the report or at the very least filed for the record:

1. <u>Page 1, section I.A.</u> The impacts of a 65-foot pool on smolts are not known, although unacceptable impacts are likely.

2. <u>Page 2, section I.B.1.</u> Trucking adult salmon for release above Ball Mountain dam should include transporting fish above the two non-Corps dams on the West River. Smolts are being produced in river sections above these structures and to restore natural reproduction to these reaches adults must be given access to them. As the Corps is to have trap-and-truck responsibility with guidance from this department, the upper West River main stem should be included in the Corps' trucking protocol.

3. <u>Page 3, section I.B.2.</u> We do not agree that there is a "consensus" that outmigration delay and smolt mortality will be minimal under a 25-foot pool. Although the studies conducted to date show little delay at the high flows examined, no studies have been done at moderate or low flows. Moderate-low flows can be expected to occur at the end of the smolt run in a normal year or at peak outmigration in a dry year. Without having the USFWS 1991 smolt mortality study results for our review, we cannot conclude mortality is minimal or acceptable.

It should not be concluded that maintenance of a 65-foot pool prior to the last weekend in April to accommodate the white water releases is not imposing a delay on some smolts attempting to leave the system. In the absence of site specific data on smolt outmigration timing and relative smolt numbers and various interests for accommodating white water releases, the proposed operational changes for Ball Mountain Dam are a reasonable interim compromise. As stated in the EA, future studies may demonstrate a further reduction in pool elevation as well as doing so in advance of the last weekend in April.

More detailed explanation should be presented for ruling out the "no pool" option. Besides potential erosion and sedimentation problems, which might be addressed by maintaining "no pool" year round and stabilizing slopes with vegetation, what were the other cost-benefits considered in the analysis? Establishing the project in a run-of-the-river mode, except during flooding events, no doubt would provide the most favorable situation for expeditious smolt passage with minimal mortality.

4. <u>Page 5.III.B.</u> If the fish trap barrier is to be raised when flows exceed 1800 cfs, how frequently do such flow events occur during the salmon upstream migration season and how will salmon getting access to the plunge pool be recovered?

5. <u>Page 9, section III.D.1.a.</u> Fry emergence from redds does not occur in early summer but from late April-early June. Parr typically spend two years in freshwater, although the length of residency can be as little as one or as long as three years.

6. <u>Page 12, section III.D.1.e.</u> Depending on what is included as habitat, only about 80% of the rearing habitat is above Townshend Dam. The salmon restoration strategic plan estimates potential smolt production from the West River to be the 28,200 stated in the EA, but this is a minimum as I pointed out in my 15 August 1991 memo to you. More current estimates based on revised habitat surveys and up-to-date juvenile salmon production inventories show potential smolt production for the last three years to be in the range of 43,000-60,000 and may be as high as 90,000. Actually only 80% of the fry have been released above Townshend Dam and 50% above Ball Mountain Dam. More current fry stocking numbers are available than for 1989 cited in the EA. This year 543,000 fry were stocked into the West River basin.

7. Page 13, section III.D.1.c. In addition to the tributaries mentioned as being stocked, Greendale and Flood Brooks are stocked. Including the subtributaries in parentheses (e.g. Winhall River (Cook Brook and Mill Brook)) is confusing. It suggests only the tributaries were stocked and not the receiving river which is not the case.

   About 20,000 smolts have been stocked almost annually below Townshend. While in comparison to fry releases this may appear "small", it does represent a significant smolt stocking. Actual outmigrating smolt numbers are not available and will never be. At best the fishery agencies can expect to monitor outmigration in relative terms once resources become available for providing counting facilities.

8. Page 13.D.2. Brown and rainbow trout are not stocked below Townshend Dam but are seasonally present there as a result of up- and downstream movement from habitats either supporting wild or stocked populations. The brown population below Ball Mountain Dam is only "sizeable" because of this department's annually stocking of that reach. Otherwise, the wild population is small.

9. Page 18.IV.A.1. Regulating Townshend Dam outflow during trap construction should be carried out in a manner that minimizes flow fluctuations and makes changes in flow regime gradually to minimize fish standing.

10. Pages 18-19.IV.A.1. and B. Better documentation of Ball Mountain lake effects on the downstream temperature regime should be discussed under both sections.

11. Page 20, IV.C.1.b. Smolts that are delayed passage, e.g. from white water release storage, may be subjected to higher predation by predatory fishes and birds. Again, data is not available to lead one to conclude delay of smolts in April is not significant. Smolts that do outmigrate under a 65-foot pool level have a high chance of dying in the process (see page 1, section I.A.). Lastly, in future years with increases of adult returns and improvements in upstream passage, salmon may reach the West River as soon as early May. Trapping could overlap with smolt outmigration and the fish barrier could inflict impingement losses on smolts. If this situation arises in the future, the conflict between barrier and smolt will have to be addressed.

12. <u>Page 24, section IV.E.</u> This section overlooks a major benefit of the restoration program at large as well as for the West River, this is the establishment of a sport fishery for "bright" salmon which are held in higher esteem than kelts by salmon anglers. The "bright" salmon fishery provides the greatest potential as a sport fishery.

As I have spoken to you today before getting these in the mail, several of the above items were discussed during our phone conversation. If you have any questions regarding the above, please contact Jay or me.

KMC:mmc

cc: J. McMenemy

State of Vermont

AGENCY OF NATURAL RESOURCES

DEPARTMENT OF FISH AND WILDLIFE

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Essex Jct., VT 05452
(802) 878-1564

☐ 324 N. Main Street
Barre, VT 05641
(802) 479-3242

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N. Springfield, VT 05150
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☐ 180 Portland Street
St. Johnsbury, VT 05819
(802) 748-8787

☐ RFD 1, Pittsford Academy
Pittsford, VT 05763
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Department of Fish and Wildlife
Department of Forests, Parks, and Recreation
Department of Water Resources & Environmental Engineering
State Geologist
Natural Resources Conservation Council

MEMORANDUM

TO: Michael Penko, Biologist, Corps of Engineers

FROM: Kenneth Cox, District Fisheries Biologist

DATE: 15 August 1991

SUBJECT: Townshend and Ball Mountain Fish Passage Draft Environmental Assessment

I've reviewed the above-referenced document and offer the following comments for your consideration when putting together the final EA. Verbage proposed to be inserted in or to substitute ones in the text are underlined and omissions are parenthetical.

1 <u>Page 1. section II.A.1.</u> Operation of the fish trap in any given year should be triggered by the passage of adult salmon through the Vernon dam, not Bellows Falls dam as stated in the report. Vernon dam is located a short distance downstream from the mouth of the West River; Bellows Falls dam is situated on the Connecticut River some distance upstream from the mouth of the West River.

2 All references to the Vermont Department of Fish and Game should be changed to Vermont Department of Fish and Wildlife, the department's current title.

3 Under Note 1 "number of fry" should be <u>numbers of fry</u>.

4 <u>Page 3, section II.B.2.</u> The two downstream passage options, a weir at the dam inlet and upstream smolt capture facility, have potential but are untried methods at the West River projects. I believe more conservative wording is appropriate here, i.e. "options <u>may</u> (instead of "would") provide effective downstream smolt passage".

5 <u>Page 3, section III.A.1.</u> The West River originates in the town of Mount Holly and not on the slopes of the mountain by that same name.

6 <u>Page 4, section III.A.1.</u> Principal towns in the West River basin should be cited to include Brattleboro, Brookline, Dummerston, Jamaica, Landgrove, Londonderry, Marlboro, Newfane, Peru, Stratton, Townshend, Wardsboro, Weston, Windham and Winhall.

7 Principal tributaries are Greendale Brook, Utley Brook, Flood Brook, Winhall River, Ball Mountain Brook, Whetstone Brook (Wardsboro Branch), Grassy Brook, Wardsboro Brook, and Rock River.

8 <u>Page 11, section III.D.1.b.</u> "To date, fish passage facilities have been constructed at <u>the five lower</u> (and not all as reported) mainstem Connecticut River dams."

9 <u>Page 12, section III.D.1.b.</u> "An average of about 210 adult salmon <u>per year</u> have returned..." "Potential reasons for <u>low</u> returns to date include <u>commercial</u> fishing pressure...and <u>predation</u>." Strike incidental catches by the shad fishery. Few adult salmon are taken in this fishery's gill nets which is not at this time a significant limiting factor for salmon returns.

10 <u>Page 12, section III.D.1.c.</u> Estimated <u>minimum</u> potential wild smolt production from the river is 28,200..." "Given this smolt output 550 <u>or more</u> adult salmon would be expected to return..."

11 In 1990 there were two reported sightings of adult salmon in the West River, i.e. one below Townshend Dam and the other (confirmed by fishery personnel) at mouth of Rock River. I am not aware of any sightings in 1991. If you are, I'd be interested in the specifics.

12 <u>Page 13, section III.D.2.</u> Rainbow trout are stocked into both Townshend and Ball Mountain Lakes; browns are released into the West River below Ball Mountain Dam. Townshend Lake does support a very limited warmwater fishery for pan fish (perch, rock bass, and an occasional small or largemouth bass) but is largely dependent on the rainbow trout stocking.

13 <u>Page 14, table 4.</u> Other species to be added to list are rock bass, *Ambloplites rupestris*; walleye, *Stizostedion vitreum*; northern pike, *Esox lucius*; mimic shiner, *Notropis volucellus*; carp, *Cyprinus carpio*; brown bullhead, *Ictalurus nebulosus*; and longnose sucker, *Catostomus cataractae*.

<u>Page 15, section III.D.5.</u> Are efforts to reintroduce osprey to
14 the projects formally approved by the Corps of Engineers and in
progress?

<u>Page 19, section IV.B.</u> It is unlikely that operation of the
15 trapping facility will have any affect on water quality (short
or long term).

<u>Page 19, section IV.C.1.a.</u> Salmon mortality caused by trapping
16 and handling should be negligible or none providing trained and
competent people are put in charge of this task.

<u>Page 21, section IV.D. Other Fish.</u> There is much conflicting
data on intraspecific competition between Atlantic salmon and
17 trout. Most of the West River and its principal tributaries
targeted for salmon restoration currently sustain low density
wild trout populations. Competition for habitat between salmon
and trout is at this time believed to be a minor threat to the
trout resources.

Sea lamprey are not known to occur above Townshend Dam,
although seasonally adults and year round ammocoete life stages
18 reside in suitable habitat below the dam. American eels,
however, can be found in very small numbers upstream of
Townshend Dam. It is very unlikely that the reintroduction of
sea lamprey above the dam as a result of salmon trapping would
create ecological problems, but for public relations purposes
every effort should be made to sort trapped fish and transport
upstream only those having fishery management benefits.

<u>Page 22, section IV.D.5.</u> Lowering Ball Mountain Lake for smolt
passage may precede the merganser egg incubation and early
19 brood rearing period. It may disturb adult nesting site
selection but have little or no impact on egg and chick
survival. If this is a concern, the current spring white water
releases would be impacting merganser production during
impoundment level lowering.

True, mergansers already exist within the project and are
exerting predatory pressure on the smolt population. But the
20 reintroduction of another fish-specific predator at a critical
time in the salmon restoration program may be an inappropriate
action. Smolts are surface oriented fish during outmigration.
Smolt passage studies undertaken by the USFWS show a passage
delay in the reservoir ranging from 2-6 hours. Since osprey
prey largely on fish distributed in the upper water column,
their presence increase smolt losses to predators by some

value. In order for the Corps to conclude no conflict between salmon and osprey restoration, was any attempt ever undertaken to quantify potential predation losses due to osprey or was the osprey project advanced on an independent track with no thought to salmon impacts? What is the daily consumption of several osprey pairs and their young over their time of residence in the project area? These questions and others should be asked before a no impact (conflict) conclusion is made.

<u>Page 24, section IV.D.E.</u> This department has made no decisions
regarding how sport fishing for salmon and other species
21 affected by salmon will be regulated. Regulatory options
identified in this section may be reasonable options but are no
more than conjecture at this time.

Thank you for giving me the opportunity to review and comment on the draft EA. If you have any questions or responses to any of the above items, please do not hesitate to call me.

KMC:mmc

cc: R. Wentworth
T. Meyers
J. McMenemy
A. Incerpi
B. Rizzo

State of Vermont

AGENCY OF NATURAL RESOURCES
103 So. Main St.
Center Building
Waterbury, Vermont 05676

'epartment of Fish and Wildlife
Department of Forests, Parks and Recreation
Department of Environmental Conservation
State Geologist
Natural Resources Conservation Council

OFFICE OF THE SECRETARY
Center Building, 2nd Floor
802-244-6951

July 23, 1991

Colonel Philip R. Harris
Division Engineer
U.S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, MA 02254-9149

ATTN: Environmental Resources Branch

RE: Public Notice
Connecticut River Basin Fish Passage Investigation
Ball Mountain and Townshend Dams

Dear Colonel Harris:

The Agency of Natural Resources has several comments with respect to the Corps plans for the enhancement of salmon passage at the two flood control dams on the West River in Vermont. The Agency is generally supportive of the Corps initiatives to advance the Atlantic salmon restoration efforts in the Connecticut River Basin and has participated in the planning process.

The Agency Department of Environmental Conservation requested a copy of the environmental assessment referenced in the June 24, 1991 public notice. To date, we have not received a copy of this document. The environmental assessment may respond, at least in part, to the formal comments that follow.

Flow Management

The Agency has been active in evaluating several proposals for hydroelectric development at Ball Mountain Dam over the last decade. As part of these evaluations, the manipulation of flows downstream to Townshend Dam has been carefully studied. An instream flow needs study was completed in 1982.

Our understanding is that the Corps presently manages the Ball Mountain Dam to release a minimum flow of 25 cfs during periods of storage and special events. The instream flow study demonstrated that fisheries habitat requirements for resident species and salmon were better accomodated by flows on the order of 90 cfs or more. For the proposed hydroelectric projects, the Agency required instantaneous run-of-the-river operations, with the release of 90 cfs, or inflow if

less, during the special storage events necessitated by the flood control operation. The Department of the Interior asked that 90 cfs, or inflow if less, be released at all times until the inflow receded to 25 cfs; for inflows less than 25 cfs, Interior asked that a fixed flow of 25 cfs be released to protect habitat.

The Agency requests that the reservoir management plan be modified to insure a strict instantaneous run-of-the-river operating scheme, except for flood regulation periods, when flows should not be reduced below 90 cfs or inflow, if less. The reservoir should be automated or manned to the extent necessary to accomplish this recommendation. The proposed gate work should be designed to assure reasonable accuracy in adjustment capability to match inflow.

For flood control management, the flows in the West River below Ball Mountain Dam can fluctuate dramatically. Such large magnitude changes in flow over short periods can be extremely disruptive and even lethal to fish and other aquatic organisms. (About ten years ago, Agency personnel actually witnessed a fish kill during a random field trip following the reduction of flows to 37 cfs.) The Corps should thoroughly investigate ramping rates that will reduce the impact of artificial fluctuations in flows.

The same comments apply to Townshend Dam. The minimum flow for Townshend would be 90 cfs multiplied by the drainage area ratio. No special studies were performed below Townshend as the project was not investigated to any great extent for hydroelectric development.

Water Level Management

In recent history, Ball Mountain Reservoir has been managed at a stage 65 feet during the summer and early fall and at a stage of 30 to 40 feet during the late fall and winter. For fish passage, the present proposal is to reduce the stage to 25 feet from late April to June 1.

During a meeting on March 5, 1990, the Agency requested an investigation of the need for the maintenance of a permanent pool at Ball Mountain. The reason for the present pool appears to be an outgrowth of a meeting that the Corps had with the Department of Fish and Game and the Water Resources Board in 1966. Fish and Game felt that the pool may reduce downstream sedimentation and provide a cold water release. The Corps determined that the pool would also inundate the unsightly disturbed work area upstream of the dam. The Agency recommended reevaluating the pool benefits in light of the fact that the pool affords very little in the way of habitat and recreational opportunities. Some of the benefits that were expected to accrue from creation of a conservation pool have not been realized. Riverine habitat and recreational use are more highly valued by the public than they has ever been.

Revegetating of borrow areas from the original construction may now be facilitated by the deposition of sediment and nutrients over the past 25 years. If the pool is reduced or eliminated, the river riparian zone vegetation should be restored in order to protect water quality and reestablish aquatic habitat.

If this option has not been thoroughly investigated, we would again ask that the Corps follow through with a study of the benefits of a reduced or eliminated pool. A reduced or eliminated pool would, of course, also provide enhanced flood storage benefits.

The spring storage management should be carefully planned to limit the period of time that the reservoir stage is elevated for whitewater releases. A written management plan for the spring and fall whitewater storage should be developed if such a plan does not currently exist.

Thank you for this opportunity to comment on this plan. Again, we support the plan, but we would recommend a more holistic approach with respect to fisheries management in the West River Basin. We applaud the Corps continuing efforts to adapt their reservoirs for multiple use of the resource.

Sincerely,

Jeffrey R. Cueto

Jeffrey R. Cueto, P.E.
Principal Hydrologist

cc: Ken Cox, VT Department of Fish and Wildlife
John Warner, U.S. Fish and Wildlife Service
Rod Wentworth, VT Department of Fish and Wildlife
Stephen Sease, Acting Deputy Secretary
Reginald LaRosa, P.E., Acting DEC Commissioner
Susan Bulmer, VT Department of Forests, Parks, and Recreation

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
400 RALPH PILL MARKETPLACE
22 BRIDGE STREET
CONCORD, NEW HAMPSHIRE 03301-4901

June 18, 1991

Mike Penko
Impact Analysis Division
U.S. Army Corps of Engineers
424 Trapelo Rd.
Waltham, Massachusetts 02254-9149

Dear Mr. Penko:

This letter is a follow-up to our March 14, 1991 letter in which we recommended that the West River be surveyed for the Federal candidate species Alasmidonta varicosa (brook floater), a freshwater mussel. The proposed project is a fish capture facility at the Townshend Lake flood control dam in Townshend, Vermont.

The June 7, 1991 survey for mussels in the West River below the Townshend Dam determined that no mussels are found immediately below the dam within the boundaries of the proposed project. The habitat is unsuitable for mussels in the vicinity of the proposed project. However, Alasmidonta varicosa was found approximately one-half mile downriver of the dam, immediately below the covered bridge. A number of other mussel species were found at this site, including Strophitus undulatus (squawfoot), Lampsilis radiata (eastern lamp mussel) and Elliptio complanata (common elliptio).

The project, as proposed, should not impact the mussels located downriver of the dam. However, should a drawdown of water be required during test pit excavations, we recommend that reductions in water levels be minimal and occur very slowly. Dramatic water level fluctuations may strand A. varicosa, since it is found in the shallower, backwater area downriver of the covered bridge. We also recommend that you monitor this site throughout the duration of the test pit sampling to ensure that mussels are not stranded. Though this is only a candidate species and is not afforded Federal protection under the Endangered Species Act of 1973 (as amended), we encourage the incorporation of protective measures to prevent the necessity for future Federal listing of this species.

We appreciate your close coordination and assistance in the survey. If you have any questions regarding our comments, please contact Susi von Oettingen at FTS 834-4411 or (603) 225-1411.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor
New England Field Offices

State of Vermont

Department of Fish and Wildlife
Department of Forests, Parks and Recreation
Department of Environmental Conservation
State Geologist
Natural Resources Conservation Council

AGENCY OF NATURAL RESOURCES
103 South Main Street, 10 South
Waterbury, Vermont 05676
802-244-7331
DEPARTMENT OF FISH AND WILDLIFE

MEMORANDUM

TO: Michael Penko, U.S. Army Corps of Engineers
FROM: Chris Fichtel, Inventory Coordinator/Zoologist
DATE: 18 June 1991
SUBJECT: Proposed fish capture facility below Townshend Dam, West River, VT

I have a correction to my letter of 12 June 1991 regarding the status of rare mussels between the Ball Mountain and Townshend Dams. The brook floater (Alasmidonta varicosa) was also documented near the mouth of Wardsboro Brook in Jamaica. A live specimen was collected there in 1979 at the same location as the eastern pearl mussel.

Sorry to have overlooked this record.

cc: Ken Cox, Vermont Fish and Wildlife Dept.
Fred Nicholson, Vermont Dept. of Environmental Conservation
Susi Von Oettingen, U.S. Fish & Wildlife Service

State of Vermont

Department of Fish and Wildlife
Department of Forests, Parks and Recreation
Department of Environmental Conservation
State Geologist
Natural Resources Conservation Council

AGENCY OF NATURAL RESOURCES
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DEPARTMENT OF FISH AND WILDLIFE

Nongame and Natural Heritage Program

12 June 1991

Mr. Michael Penko
Impact Analysis Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02254-9149

RE: Proposed fish capture facility below Townshend Dam, West River, VT

Dear Mike:

As you are aware from our field survey of the West River last week for *Alasmidonta varicosa*, habitat for mussels is poor for approximately 0.4 mile downstream of the Townshend Dam. The river current is fast and the bottom is rocky with virtually no sandy substrate, attributes which are not conducive to supporting these mussels. Suitable habitat exists immediately downstream of the covered bridge (approximately 0.4 mile below the dam) and several *Alasmidonta varicosa* of various age classes were found there.

I am satisfied that the project, as proposed, should not adversely impact the mussel bed below the covered bridge provided that certain precautions during test pit excavation and capture facility construction are taken. Drawdown of the river for test pit excavation should be minimal and done slowly to prevent leaving mussels stranded. Someone, preferably you, should monitor the mussel bed during this operation. During construction of the capture facility, coffer dams should be installed to minimize sedimentation downstream. I do not foresee sedimentation being a problem because of the rocky stream bottom, but I recommend a conservative approach. The same precautions regarding drawdown of the river should be applied during construction of the facility.

We do have a record of the eastern pearl mussel *Margaritifera margaritifera* from the West River between Ball Mountain and Townshend Dams. The 1979 record is from near the mouth of Wardsboro Brook. This species is currently proposed for

threatened status in Vermont under state statute 10 V.S.A. Chapter 123, but has no federal status. There are no records for Alasmidonta varicosa between the dams.

I enjoyed meeting you last Friday, and appreciated your help with the mussel survey.

If you have any questions, please give me a call.

Sincerely,

Chris Fichtel

Christopher Fichtel
Inventory Coordinator/Zoologist

cc: Ken Cox, Vermont Fish and Wildlife Dept.
Fred Nicholson, Vermont Dept. of Environmental Conservation
Susi Von Oettingen, U.S. Fish & Wildlife Service

State of Vermont

Department of Fish and Wildlife
Department of Forests, Parks and Recreation
Department of Environmental Conservation
State Geologist
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DEPARTMENT OF FISH AND WILDLIFE

April 12, 1991

Joseph Ignazio
Director of Planning
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02254-9149

RE: Townshend and Ball Mountain Dams
West River, VT

Dear Mr. Ignazio:

This responds to your letter dated February 25, 1991 requesting this department's comments on your proposed plan to provide upstream and downstream fish passage at the two flood control projects located on the West River in Vermont.

Beginning in 1983 this department sought and received the support of U.S. Senators Stafford and Leahy for legislation which would grant the Corps of Engineers (COE) authorization to provide fish passage facilities at Townshend and Ball Mountain dams. As you know, COE has since then been given this authorization and funds for making the necessary fish passage improvements at these projects. The preliminary plan you have submitted for our review represents the coordinated efforts of COE, U.S. Fish and Wildlife Service and this department, therefore we strongly support implementation of fish passage measures at both dams. Once fish passage facilities are in place and performing effectively, salmon restoration to the West River basin and Connecticut River will be enhanced greatly. This department looks forward to implementation of these improvements at the earliest possible date.

Department staff review of your proposal has identified several potential environmental impacts which we request that you address prior to finalizing the project plan. These are as follow:

<u>Aquatic Habitat</u>

Dredging several thousand cubic yards of river substrate material from the Townshend dam tailrace and installation of submerged gridblocks represents a significant alteration and permanent loss of fish and macroinvertebrate habitat. Past fish population sampling undertaken by this department in the vicinity of the proposed bed alteration found a variety of fishes inhabit the area among which are Atlantic salmon parr, brown and brook trout, and smallmouth bass. The COE is requested to address both short term (construction) and long term (maintenance) impacts of this alteration on fishes and macroinvertebrates, in general, inhabiting the project area.

This department's Nongame and Natural Heritage Program staff has brought to your attention the possibility of two rare mussel species, the brook floater (*Alasmidonta varicosa*) and the eastern pearly mussel (*Margaritifera margaritifera*), either occurring in or in vicinity of the Townshend project. A survey will be undertaken this summer to ascertain whether or not the species are threatened by the project and, if so, appropriate actions for their protection will be recommended.

<u>Water Quality</u>

Effects of maintaining a 25-foot pool or run-of-the-river at the Ball Mountain project during the smolt outmigration period on water quality in the impoundment as well as below the dam should be thoroughly addressed. Elevated turbidity and sedimentation levels resulting from reservoir drawdown could degrade aquatic habitat with negative affects on trout, and macroinvertebratess salmon residing within the project area.

Lastly, I wish to draw your attention to two minor corrections to the plan under the section titled "Status of Atlantic Salmon Restoration Efforts in the West River":

(1) Paragraph 2, line 4. Salmon are captured for broodstock at Holyoke dam and not the Turners Falls dam.

(2) Paragraph 2, lines 5-8. About 10% of the salmon observed at Holyoke dam are allowed to continue migrating upriver rather than removed for broodstock. Of the 10 salmon that made it to Vernon dam during the 1990 run, as many as four may have entered the West River. One fish was confirmed to be holding at the mouth of the Rock River (located downstream of Townshend dam). Another salmon was reportedly caught by an angler at the Townshend dam outlet pool. This event occurred in June, not May, and the fish escaped being landed.

Thank you for the opportunity to comment on this proposal. We also wish to continue assisting you with the development and implementation of passage facilities at the two West River projects. If you have any questions, please contact Mr. Kenneth Cox in the Springfield Regional Office at (802) 886-2215.

Sincerely yours,

J. Timothy Van Zandt
Commissioner

TVZ/KMC/mmc

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
400 RALPH PILL MARKETPLACE
22 BRIDGE STREET
CONCORD, NEW HAMPSHIRE 03301-4901

REF: Ball Mountain

April 1, 1991

Joseph Ignazio, Chief
Planning Directorate
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254-9149

Dear Mr. Ignazio:

This responds to your letter dated February 25, 1991, requesting our comments on your proposed plan to provide for upstream and downstream fish passage at the Ball Mountain Lake and Townshend Lake flood control projects located on the West River in Vermont.

We strongly support the implementation of fish passage measures at the Ball Mountain and Townshend dams. Both upstream and downstream passage facilities will greatly benefit the Connecticut River Anadromous Fish Restoration Program. However, the activities you have proposed would have some environmental impacts that should be addressed.

The following comments are provided in accordance with the Fish and Wildlife Coordination Act.

Fish Habitat

The upstream fish passage option you have selected will require the excavation of approximately 1,000 cubic yards of material from the stream bed, and the replacement of approximately 1,500 square feet of natural stream bed with submerged gridblock below Townshend Dam.

These activities would alter or destroy fish habitat in the affected area. You should provide an assessment on the extent of these impacts on resident and anadromous fish and other aquatic organisms. You may wish to consult with the Vermont Department of Fish and Game on their management plan for this portion of the West River.

Riparian Habitat

The proposed construction would destroy several hundred square feet of riparian shrub-scrub vegetation. Although the overall area is small, the amount of riparian vegetation impacted by project construction should be minimized as much as possible. Exposed soils should be revegetated, with native species used if possible.

Reservoir Temperatures

The proposal to draw down Ball Mountain Lake from 65 feet deep to 25 feet deep in May could alter the temperature regime of the reservoir and resultant discharges in May and later in the summer. This potential impact could be more pronounced if the no-pond, run-of-river operating scenario is implemented. The West River downstream from Ball Mountain Dam is managed for a tailwater brown trout fishery, and for Atlantic salmon rearing. Any temperature increases could have adverse impacts on these species, and on water quality in the West River.

The time of year of the operational changes, and other factors may minimize temperature increases due to solar radiation. However, at a minimum, water temperatures in the reservoir and of dam discharges should be monitored following implementation of the proposed changes.

Sediment and Turbidity

The construction activities at Townshend Dam could result in the discharge of sediment and turbid outflows from the construction site. All efforts should be made to minimize such discharges.

Conversion to a no-pond, run-of-river system could also result in the discharge downriver of sediment that has built up in the reservoir over the years. Such discharges could adversely affect fish and benthic organisms such as aquatic insects and mollusks. The quantity of sediment that would be discharged by such an operation should be evaluated. In addition, the sediments should be tested for metals prior to implementation of toxic organic compounds including pesticides and herbicides should also be evaluated. Measures should be investigated and implemented as needed to minimize the impacts of sediment discharges.

Thank you for the opportunity to comment. If you have any questions regarding these comments, please contact Mr. John Warner of this office at (FTS) 834-4411, or (603) 225-1411.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor
New England Field Offices

STATE OF VERMONT
AGENCY OF DEVELOPMENT AND COMMUNITY AFFAIRS

DIVISION FOR HISTORIC PRESERVATION
Preserving Vermont's historic, architectural and archeological resources

March 22, 1991

Joseph Ignazio
Department of the Army
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, MA 02254

Re: Townshend Lake Fish Passage, Townshend and Jamaica. Corps.

Dear Mr. Ignazio:

Thank you for the opportunity to comment on the above-referenced project.

The Division for Historic Preservation has reviewed this undertaking according to the standards set forth in 36 C.F.R. 800, regulations established by the Advisory Council on Historic Preservation to implement Section 106 of the National Historic Preservation Act. Project review consists of identifying the project's potential impacts to historic buildings, structures, historic districts, historic landscapes and settings, and known or potential archeological resources.

The proposed project will not effect any properties of historic, architectural or archeological significance that are listed on or eligible for inclusion in the National Register of Historic Places.

Sincerely,

Eric Gilbertson
Director/State Historic Preservation Officer

EG/SCJ

cc: Townshend Planning Commission
Jamaica Planning Commission
Windham Regional Planning & Development Commission

Office location: 58 East State Street
Mailing address: Pavilion Building
(802) 828-3226
Montpelier, Vermont 05602

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
400 RALPH PILL MARKETPLACE
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March 14, 1991

Joseph Ignazio, Chief
Planning Directorate
U.S. Army Corps of Engineers
424 Trapelo Rd.
Waltham, MA 02254-9149

Dear Mr. Ignazio:

This responds to your letter dated February 25, 1991 requesting information on the presence of Federally listed and proposed endangered or threatened species in relation to the proposed plan to provide passage of salmon at the Ball Mountain Lake and Townshend Lake flood control projects in Vermont. A fish capture facility constructed downstream of the Townshend Dam outlet, and management of the Ball Mountain pool for downstream passage of smolts are the two primary components of the proposal.

Based on information currently available to us, no Federally listed or proposed threatened and endangered species under the jurisdiction of the U.S. Fish and Wildlife Service are known to occur in the project area, with the exception of occasional transient endangered bald eagles (*Haliaeetus leucocephalus*) or peregrine falcons (*Falco peregrinus anatum*). However, *Alasmidonta varicosa*, a mussel of the Unionid family has been recommended for addition to the Animal Notice of Review as a candidate category 2[1] species and is present in the West River. The Notice of Review is expected to be published in the Federal Register this year, at which time *Alasmidonta varicosa* would be officially recognized as a candidate species. *Margaritifera margaritifera* (a mussel of the Margaritifera family) has also been found in the West River. Both species have been proposed for State listing as threatened. We suggest that you contact Chris Fichtel of the Vermont Natural Heritage Program, Agency of Natural Resources, Center Bldg., 103 S. Main St., Waterbury, VT 05676, (802) 244-7340 for information on these species or state listed species that may be present.

There may be impacts to mussel fauna in the West River from the proposed fish capture facility if work in the river bed involves either dredging or the placement of structures. Drastic changes in water levels may also adversely impact mussels immediately below or above the Ball Mountain flood control facility. While Federal candidate species are not afforded protection under the Endangered Species Act, the U. S. Fish and Wildlife Service (FWS) encourages their consideration in environmental planning. If unnecessary impacts to candidate species can be avoided, the likelihood that

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[1]Category 2 comprises taxa for which information now in possession of the Service indicates that proposing to list as endangered or threatened is possibly appropriate, but for which conclusive data on biological vulnerability and threat are not currently available to support proposed rules.

they will require the protection of the Act in the future is reduced. We recommend that a qualified biologist survey the areas potentially impacted by either the construction of the fish capture facility or the water level management for smolt migration. *Alasmidonta varicosa* as a candidate (once it has been officially recognized) should be considered in the development of the project.

This response relates only to endangered species under our jurisdiction. It does not address other legislation or our responsibilities under the Fish and Wildlife Coordination Act. A letter reviewing this project in accordance with the Fish and Wildlife Coordination Act will be sent under separate cover.

A list of Federally designated endangered and threatened species in Vermont is included for your information. Thank you for your cooperation and please contact Susi von Oettingen of this office at (603) 225-1411 if we can be of further assistance.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor
New England Field Offices

<u>FEDERALLY LISTED ENDANGERED AND THREATENED SPECIES</u>
<u>IN VERMONT</u>

<u>Common Name</u>	<u>Scientific Name</u>	<u>Status</u>	<u>Distribution</u>
FISHES:			
NONE			
REPTILES:			
NONE			
BIRDS:			
Eagle, bald	<u>Haliaeetus leucocephalus</u>	E	Entire state-migratory
Falcon, American peregrine	<u>Falco peregrinus anatum</u>	E	Entire state-reestablishment to former breeding range is in progress
MAMMALS:			
Bat, Indiana	<u>Myotis sodalis</u>	E	Southwestern Counties
Cougar, eastern	<u>Felis concolor couguar</u>	E	Entire state-may be extinct
MOLLUSKS:			
Mussel, Dwarf Wedge	<u>Alasmidonta heterodon</u>	E	Windsor (Conn. River Valley)
PLANTS:			
Jesup's milk-vetch	<u>Astragalus robbinsii</u> var. <u>jesupi</u>	E	Connecticut River Valley
Small Whorled Pogonia	<u>Isotria medeoloides</u>	E	Chittenden County
Bulrush, Northeastern	<u>Scirpus ancistrochaetus</u>	PE[1]	Windham County

[1] Proposed Endangered, Final Rule due May 1991

Rev. 11-13-90

State of Vermont

Department of Fish and Wildlife
Department of Forests, Parks and Recreation
Department of Environmental Conservation
State Geologist
Natural Resources Conservation Council

AGENCY OF NATURAL RESOURCES
103 South Main Street, 10 South
Waterbury, Vermont 05676
802-244-7331
DEPARTMENT OF FISH AND WILDLIFE

Nongame & Natural Heritage Program

11 March 1991

Mr. Michael Penko
Impact Analysis Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02254-9149

RE: Proposed fish capture facility below Townshend Dam, West River, VT

Dear Mr. Penko:

There are no known occurrences of endanngered or threatened species at the project site. However, our records indicate that the brook floater (Alasmidonta varicosa), a freshwater unionid mussel species, occurs in the West River both upstream and downstream from the site. The brook floater is experiencing population declines throughout much of the species' range. The U.S. Fish & Wildlife Service is studying this species as a potential candidiate for federal listing and the State of Vermont has proposed the brook floater for state threatened status. The West River is the only known stream in Vermont to support the brook floater. Another mussel proposed for state threatened status, the eastern pearl mussel (Margaritifera margaritifera), is known to occur in the West River upstream from Townshend Dam.

We plan to undertake a field survey for these species during the summer of 1991 to identify any possible concerns. If these species are found and any concerns are identified, we will recommend appropriate actions.

Thank you for contacting our office.

Sincerely,

Chris Fichtel

Christopher Fichtel
Inventory Coordinator/Zoologist

cc: Ken Cox, District Fisheries Biologist
Fred Nicholson, Stream Alterations Engineer
Susi Von Oettingen, U.S. Fish & Wildlife Service

Bernie Toothaker
Dam Release Coordinator - A.M.C.
Inter Chapter Canoe Committee
1 Hickory Lane
West Newbury, MA 01985

February 13, 1990

Mr. Joseph L. Ignazio
Chief, Planning Division
Basin Management Branch
Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, MA 02254-9149

Dear Mr. Ignazio,

Thank you for your letter of invitation dated February 8, 1990. Unfortunately, due to previous commitments, I will not be able to attend the technical working group meeting scheduled for February 22, 1990.

I have taken the liberty to mail a copy of your letter to a few key individuals I thought should be notified. Perhaps they may have some useful input.

Would you, or someone from your staff, keep me apprised of any resolution made at the meeting? The West River is truly a treasure to the white water boaters of the Northeast.

Sincerely,

Bernie Toothaker

Bernie Toothaker
Dam Release Coordinator - A.M.C.

BST:bst

cc: Mr. Richard Heidebrecht

State of Vermont

Department of Fish and Wildlife
Department of Forests, Parks and Recreation
Department of Environmental Conservation
State Geologist
Natural Resources Conservation Council

AGENCY OF NATURAL RESOURCES
103 South Main Street, 10 South
Waterbury, Vermont 05676
802-244-7331
DEPARTMENT OF FISH AND WILDLIFE

February 6, 1990

Mr. Vyto L. Andreliunas
Chief, Operations Division
Department of the Army
New England Division,
Corps of Engineers
424 Trapelo Road
Waltham, MA 02254-9149

Dear Mr. Andreliunas:

The Vermont Department of Fish and Wildlife is quite concerned about the impact of the Corps of Engineer's Ball Mountain Dam on Atlantic salmon smolts migrating from the upper West River basin during their seaward migration. As you know, Congress has authorized the Corps to construct fish passage facilities at its dams on the West. However, the design and construction of safe downstream passage will take at least a few years and in the interim period large numbers of salmon smolts will be attempting to migrate past this dam annually. Enclosed is a proposal to facilitate passage of smolts through Ball Mountain Dam before downstream passage facilities are in place at this facility.

I am requesting your review of this proposal and a meeting of appropriate staff people from our respective agencies to discuss this matter. I believe the proposal, if followed, will significantly improve the passage of salmon smolts without compromising your flood control mission or the recreational whitewater releases. Ken cox, Fisheries Manager from our Springfield office would be representing our Department. Ken can be reached at (802) 886-2215. If you agree with the review of this proposal, I would suggest your staff person contact Ken directly. I look forward to your response.

Sincerely,

Angelo Incerpi

Angelo Incerpi
Director of Fisheries

AI/JRM/rlb

cc: Kenneth Cox, District Fisheries Manager
Theodore Meyers, Connecticut River Coordinator, USFWS

DRAFT

INTERIM DOWNSTREAM PASSAGE PROPOSAL FOR BALL MOUNTAIN RESERVOIR

VERMONT DEPARTMENT OF FISH AND WILDLIFE

Background

The West River is a major component of the Connecticut River Atlantic Salmon Restoration Program. Juvenile Atlantic salmon have been stocked in the West River basin since 1981. Since 1987, over 400,000 juvenile salmon (mostly fry) have been stocked in the West River and its tributaries annually. More than half of these fish have been stocked upstream of the U.S. Army Corps of Engineers Ball Mountain Reservoir flood control dam. The salmon smolts produced above the dam must migrate through Ball Mountain Dam to continue their downstream journey to the ocean.

Current conditions require smolts, which migrate near the surface of the water column, to dive 65 feet to reach the outlet at the bottom of Ball Mountain Reservoir at normal pool elevation. This is believed to greatly delay migrating smolts and exposes them to increased predation risks and/or results in smolt reversion to parr.

The winter pool level has a design depth of 25 feet and is normally maintained at 30-50 feet during the winter months until spring runoff. After the runoff has subsided the reservoir is maintained at the summer pool level of 65 feet.

The United States Congress has authorized the Corps of Engineers to construct upstream and downstream fish passage facilities at its dams on the West River and has appropriated $100,000 to study and plan these facilities. However, construction of downstream fish passage facilities at Ball Mountain Reservoir is most optimistically at least a few years away and before then large numbers of salmon smolts will be attempting to migrate past the dam annually. The safe passage of these smolts is of utmost importance to the salmon program and to the ultimate restoration of a salmon population to the West River.

Proposal

In the interim period before construction of downstream passage facilities at Ball Mountain Reservoir, the Vermont Department of Fish and Wildlife requests that the Corps of Engineers modify the operation of the reservoir to facilitate passage of salmon smolts. During the primary smolt migration period (April 1 - June 1) we request that the Ball Mountain Reservoir pool be maintained at the winter design level of 25 feet, or lower if possible. Of course, this reduced pool level could not be maintained during flood events or storage for the spring whitewater releases. If a reduced pool level can be maintained during the smolt migration period, delay and mortality of migrating smolts will likely be significantly reduced.

United States Senate

COMMITTEE ON APPROPRIATIONS
WASHINGTON, DC 20510-6025

November 22, 1989

Colonel Daniel M. Wilson
Division Engineer
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02254

Dear Colonel Wilson:

I am writing to urge the Corps to act, as soon as possible, on planning and feasibility work for fish passage facilities at the Corps' Townshend and Ball Mountain dams in Vermont.

I understand that Commissioner J. Timothy Van Zandt of the Vermont Department of Fish and Wildlife, and Chairman David F. Egan of the Connecticut River Atlantic Salmon Commission have recently written to you to express their interest in working on this project. I endorse their offers to cooperate in timely fashion with the Corps on this planning and feasibility work.

As you know, this project was authorized in the Water Resources Development Act (P.L. 99-662) through the efforts of former Vermont Senator Robert Stafford. This year, Congress appropriated $100,000 for the design and feasibility stage of the project in P.L. 101-101, the Energy and Water Development Act for Fiscal Year 1990.

For several years the project -- because it is part of an overall effort to improve water quality in the Connecticut River and its tributaries and especially, to hasten the return of the Atlantic salmon to these waters -- has been a high priority for Senator Stafford and me. Now that federal monies are finally available to begin the effort, we hope that we can count on the cooperation of the Corps.

I appreciate your consideration of this request. And I look forward to hearing from you on the Corps' plans to initiate work on the project. Thank you.

Sincerely,

Patrick Leahy

PATRICK LEAHY
United States Senator

PJL/jpr

State of Vermont

Department of Fish and Wildlife
Department of Forests, Parks and Recreation
Department of Environmental Conservation
State Geologist
Natural Resources Conservation Council

AGENCY OF NATURAL RESOURCES
103 South Main Street, 10 South
Waterbury, Vermont 05676
802-244-7331
DEPARTMENT OF FISH AND WILDLIFE

October 30, 1989

Colonel Daniel M. Wilson
Division Engineer
U. S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, MA 02254-9149

Dear Colonel Wilson:

Since the Corps of Engineers was given authorization to develop, operate and maintain fish passage projects at Townshend and Ball Mountain dams on the West River under P.L. 99-662 (Water Resources Development Act), no monies were appropriated to carry out these important projects. Most recently this Department was informed by Senator Leahy's office that the FY 1990 Energy and Water Appropriations Bill (P.L. 101-101) includes $100,000 earmarked for the Corps to conduct the necessary planning and feasibility studies for these projects.

In the interest of starting this process, I am requesting the Corps begin consultation with the U. S. Fish and Wildlife Service (USFWS) and this Department toward resolving the up and downstream fish passage issues on the West River. The issues involve provisions for upstream passage to be constructed at Townshend dam and downstream passage facilities for both Townshend and Ball Mountain dams. As early as March 1984 the USFWS developed preliminary conceptual plans for a fish trap-and-truck facility at Townshend dam. A copy of this design was then provided to the Corps.

While certainly much must be done to resolve passage problems at these facilities, it is critical to the salmon restoration program in the West River basin that planning begin as soon as possible. As you may know, the West River is one of our significant tributaries in the overall restoration program and has received increasing numbers of juvenile salmon in recent years.

In 1987 a record number of salmon fry (386,000) were released to the West River and several of its tributaries. Approximately 60 percent of these were stocked above Ball Mountain dam and, as smolts migrating to sea in the Spring 1989, had to pass through both dams at which there are no provisions for effective and efficient downstream fish passage. The adults surviving from the 1987 fry release as well as from other parr and smolt releases in the West River, are expected to return in 1991 and at that time will be unable to pass above Townshend dam. Subsequent juvenile salmon stockings in 1988 and 1989 have also been in the order of those released in 1987. At a minimum, this level of stocking will continue into the future. The West River is on the threshold of having salmon runs restored to it providing the current fish passage problems can be resolved. The fishery agencies involved in the regional program look forward to the Corps making the needed improvements at these projects.

This Department is also aware of the Corps' plans to make substantial repairs to the Townshend dam outlet works. Since this can influence the ultimate design of a fish trap-and-truck facility and downstream fish passage there, I recommend these construction projects be coordinated with one another.

I look forward to our continuing cooperation with you and your staff in the planning, construction and operation of these projects.

Sincerely,

J. Timothy Van Zandt

J. TIMOTHY VAN ZANDT
Commissioner

JTV/svb.12
cc: David Egan, Salmon Commission
Ted Myers, CT River Salmon Coordinator
John Romano, Sen. Leahy's Office
Ben Rizzo, USFWS

APPENDIX B

HYDROLOGIC, HYDRAULIC AND WATER QUALITY EVALUATION

APPENDIX B

WEST RIVER FISH PASSAGE FACILITIES
BALL MOUNTAIN AND TOWNSHEND LAKES
HYDROLOGY, HYDRAULICS, AND WATER QUALITY EVALUATION

PREPARED BY
HYDRAULICS AND WATER QUALITY BRANCH
WATER CONTROL DIVISION
ENGINEERING DIRECTORATE

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASSACHUSETTS

JANUARY 1992

WEST RIVER FISH PASSAGE FACILITIES
BALL MOUNTAIN AND TOWNSHEND LAKES
HYDROLOGY, HYDRAULICS, AND WATER QUALITY EVALUATION

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WEST RIVER FISH PASSAGE FACILITIES
BALL MOUNTAIN AND TOWNSHEND LAKES
HYDROLOGY, HYDRAULICS, AND WATER QUALITY EVALUATION

1. INTRODUCTION

As part of the program to reestablish anadromous Atlantic salmon runs to the Connecticut River, the Corps has been charged by Congress to design and build upstream and downstream fish passage facilities on the West River at Ball Mountain and Townshend Lakes in Vermont (locations of these projects are shown on figures 1 and 2). During meetings with representatives of the U.S. Fish and Wildlife Service (USFWS) and the Vermont Department of Fish and Wildlife, it was agreed that the best way to provide upstream passage was by trapping salmon at a fish barrier below Townshend Lake and trucking them to West River tributaries above Townshend and Ball Mountain Lakes. Downstream passage will be made possible by lowering the pool at Ball Mountain Lake in the spring to allow fish to get through the existing outlet works. Minor modifications will be made to improve downstream fish passage over the existing Townshend Lake outlet works; these include cutting a 1 by 1 foot notch in the existing weir and creating a plunge pool below the weir. In order to minimize river stages during the July to November instream construction period for the fish trap and barrier, discharges from Townshend Lake will be kept below 1,500 cfs except during flood control operations. This will likely cause frequent pool level increases and flooding of the recreation area during construction. Maximum temporary storage utilized at Ball Mountain and Townshend Lakes during construction will be limited to the equivalent of 1 inch of runoff from the upstream watershed.

This report describes hydraulics of the fish barrier and trap, temporary cofferdams, and modifications to Townshend Dam outlet works; and water quality effects of lowering the pool at Ball Mountain Lake to facilitate downstream fish passage, and raising the pools at Townshend and Ball Mountain Lakes during construction of the fish barrier and trap. The Reservoir Regulation Evaluation Appendix discusses construction storages at Ball Mountain and Townshend Lakes in detail including the rationale for using 1-inch runoff storage.

2. HYDROLOGY

a. General. The West River watershed is located in southern Vermont within the confines of Windham, Bennington,

Rutland and Windsor Counties. It has a drainage area of 423 square miles of which 278 and 172 square miles lie upstream from Townshend and Ball Mountain Lakes, respectively. Generally elongated in shape, the watershed has a length of approximately 38 miles and a maximum width of 18 miles. Elevations vary from 220 feet NGVD at the mouth of the river to 3,500 feet NGVD at several points on the watershed divide.

b. Topography. General watershed topography between Ball Mountain Lake and the Connecticut River is hilly with steep wooded slopes. Upstream from Ball Mountain Lake the watershed is mountainous with few natural or artificial ponds. In general, the drainage area is conducive to rapid runoff.

c. Streamflow. There is a USGS gage on the West River at Newfane, Vermont approximately 6.8 miles downstream from Townshend Dam. Drainage area at the gage is 308 square miles. Based on 68 years of record, from 1919 to 1987, and proportioning flows based on the 278 to 308 drainage area ratio between Townshend Lake and the Newfane gage, estimated average and minimum flows below Townshend Dam are presented in table 1. Maximum flows are also presented in table 1 but only for the years 1961 to 1987 to include the effects of Ball Mountain and Townshend Lakes on peak discharges.

3. HYDRAULICS OF UPSTREAM PASSAGE FACILITIES

a. General. Upstream fish passage facilities will consist of a fish trapping and trucking facility below Townshend Dam with a fish barrier across the river to direct fish to the trap. The following paragraphs describe the hydraulic analyses of these features.

b. Structures. The fish trapping facilities consist of a barrier and trap about 315 feet below the conduit outlet. Plate B-1 shows the layout of barrier and trap.

(1) Fish Barrier. The barrier is 120 feet long and made of 1/2-inch bars spaced 2 inches on center. This spacing allows downstream passage of smolts and minimizes debris blockage while still preventing upstream-migrating salmon from getting wedged between the bars. Invert of the first 30 feet of the barrier (on the right hand side) is at elevation 453 feet NGVD. The remainder is at invert 454 feet NGVD; this approximates conditions in the river channel. Top of the barrier is set at elevation 459.2 feet NGVD, making the barrier 6.2 feet high at the low flow channel and 5.2 feet high for the rest of the barrier.

CORPS OF ENGINEERS U. S. ARMY

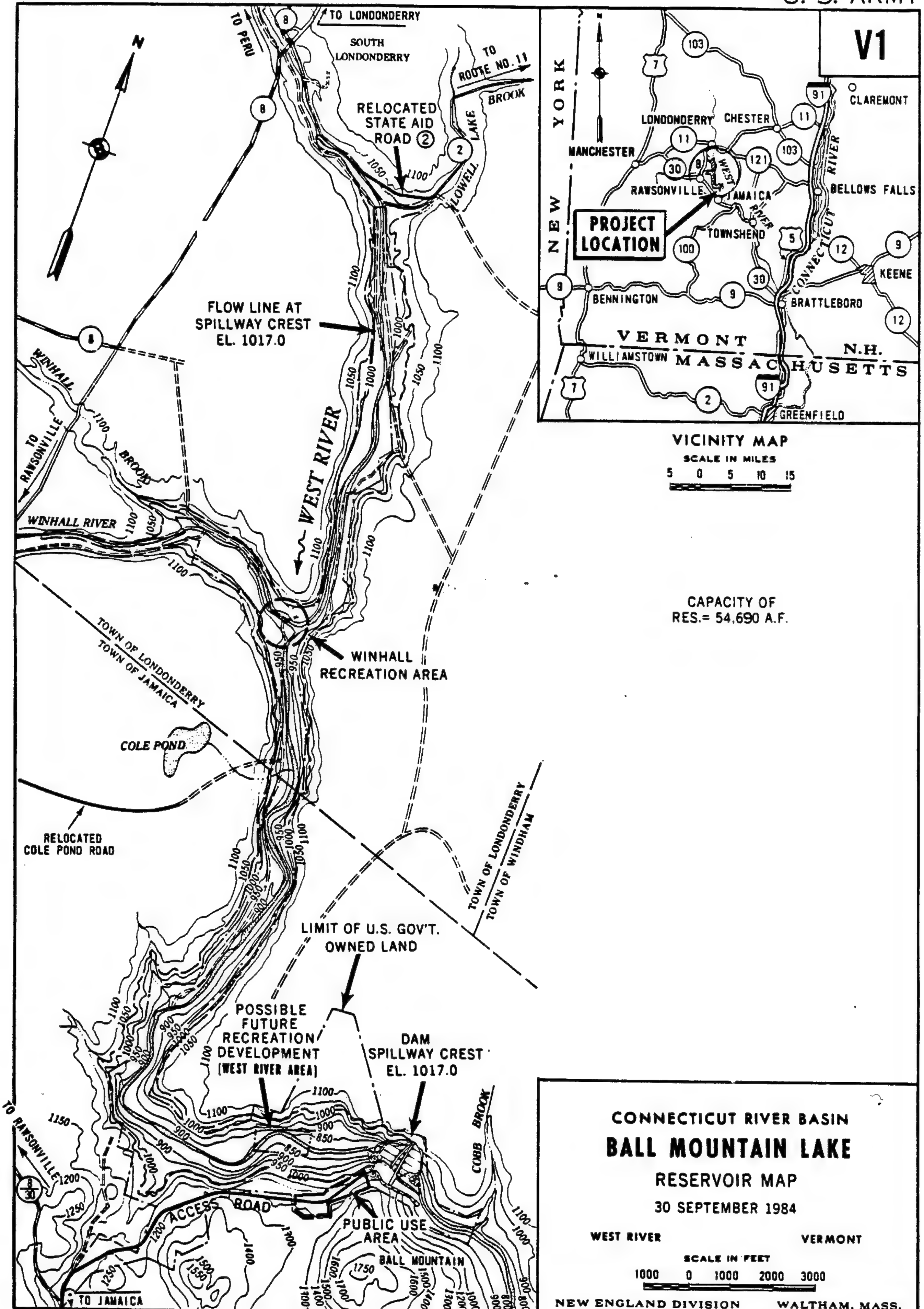
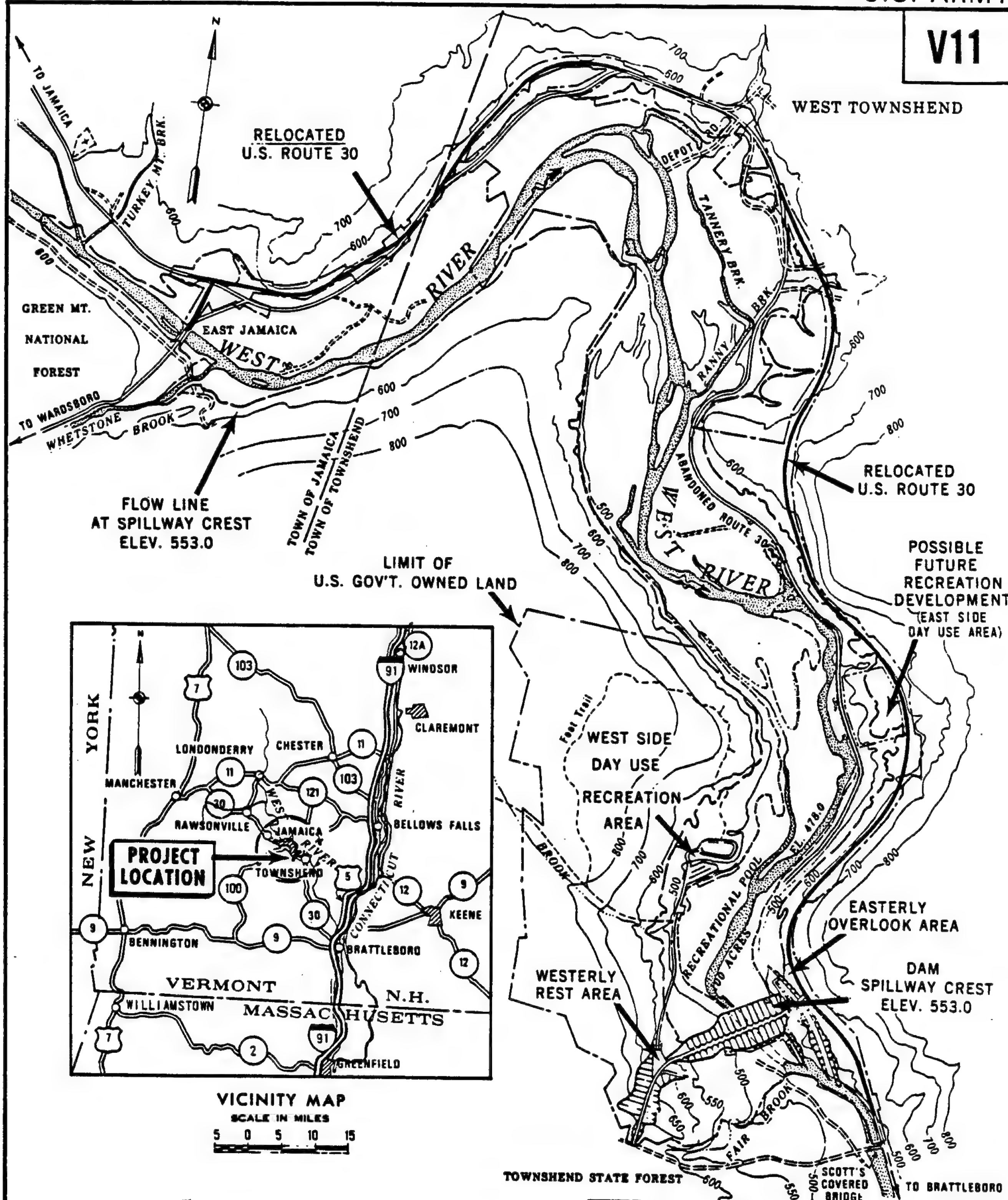


Figure 1



CAPACITY OF
RES. = 33,600 A.F.

CONNECTICUT RIVER BASIN

TOWNSHEND LAKE

RESERVOIR MAP

30 SEPTEMBER 1984

WEST RIVER VERMONT

SCALE IN FEET
500 0 500 1000 1500

NEW ENGLAND DIVISION WALTHAM, MASS.

TABLE 1

AVERAGE DAILY FLOWS ON THE WEST RIVER AT TOWNSHEND LAKE (CFS)
1919 - 1987
ADJUSTED BY DRAINAGE AREA FROM NEWFANE GAGE TO TOWNSHEND LAKE

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Year
Daily	283	497	505	413	390	979	2007	900	360	184	140	181	569
Maximum*	5,230	3,920	6,030	4,120	5,940	7,700	9,000	7,090	6,770	4,480	4,660	3,820	9,000
Minimum	16	22	52	60	59	59	139	58	15	13	7	12	7

*Maximum flows were taken from the period 1961-87 to include only those years Ball Mountain and Townshend Lakes were in operation

(2) Fish Trap. The trap is 6-1/2 feet wide and located on the right hand side of the barrier. The main part of the trap is the holding area which has a grated floor that can be raised to force fish into the lifting bucket when loading fish into a truck. Invert elevation of the downstream opening is 453 feet NGVD; however, to provide sufficient depth of water for fish under low flow conditions, the holding area floor is set at elevation 450 feet. Additional features include upstream racks to stop the fish, and a downstream V-shaped bar rack pointing upstream towards the holding area. This rack has an opening at its apex to allow fish to enter but not leave the holding area. There is also a downstream gate to control velocities through the structure. Upstream and downstream racks are made with the same material as the barrier racks.

(3) Access Road. Access to the fish trap and barrier will be provided with a road constructed on the right bank of the river. This road will be built up to elevation 463.6 feet NGVD which is about 2 feet higher than the existing ground. This elevation was calculated to prevent overtopping and erosion during normal events, but provide overflow capacity if high discharges should occur with the barrier racks still in place. The road will be built after construction of the barrier and trap in order to maintain flow area around the cofferdams.

c. Design Conditions. Design flow for the trap is 1,500 cfs. According to the USFWS, fish are not likely to travel up the river when flows exceed 1,500 cfs. For the 1,500 cfs flow condition, the barrier should extend 1 foot above the upstream water depth to prevent fish from leaping over it. Hydraulic calculations assumed bar racks were 25 percent clogged with debris. Racks are designed to be removed for high flows of 5,000 cfs or greater. Maximum velocities in the fish holding area should be kept to 2 fps to prevent exhausting the fish, but the velocity leaving the trap should be equal to that in the river to attract the fish. Originally, a moveable gate at the downstream end of the trap was proposed to throttle flows to meet these conditions. However, USFWS personnel objected to the idea of closing off part of the entrance believing that fish would be more attracted to an open area even if velocities were lower. The revised plan does not have a moveable gate but includes stoplog slots near the entrance to the trap. If it is found desirable in the future, a frame with an opening on one side can be dropped into these slots. This frame will direct flows to one side causing increased velocities that may be more effective in attracting fish. Minimum depth available

to the fish should be 3 feet in the holding area. USFWS personnel would like to restrict approach velocities to the barrier to a maximum of 2 fps for flows up to 1,500 cfs. However, even with the bar racks 25 percent clogged with debris, the approach velocity is on the order of 2 to 3 fps. Keeping the approach velocity below 2 fps for 1,500 cfs flows, is unachievable without building a much larger fish barrier.

d. Backwaters. In order to determine flow depths at the barrier under different flow conditions, backwater depths were calculated using the HEC-2 Water Surface Profiles program, version 4.6.0, February 1991. Manning's "n" values were taken to be 0.03 for the channel and 0.045 for overbank sections. Concrete sections of the trap and barrier had an assumed "n" of 0.015. Contraction and expansion coefficients were taken as 0.3 and 0.5, respectively. Backwaters were calculated up to the barrier from a field-measured stage-discharge cross section 618 feet downstream from the outlet. Figure 3, the rating curve for this section, is based on regulated flows from the dam and stage measurements. No velocity measurements were made.

e. Bar Rack Losses. Losses through bar racks were computed using the method given in chapter X of Design of Small Dams (2nd Ed., 1977) as a function of the velocity head through the bars. A loss coefficient of 0.77 was calculated using equation 11:

$$Kt = 1.45-0.45An/Ag-(An/Ag)^2$$

where: Kt = loss coefficient
An = net area through the rack bars
Ag = gross area of racks and supports.

Conditions with flow over the racks were analyzed assuming orifice flow through the bars with an orifice coefficient of 0.5, and weir flow over the top with a weir coefficient of 3.0. Where the racks were submerged by tailwater, the weir coefficient was reduced using the method presented in King and Brater's Handbook of Hydraulics for analysis of submerged weirs. For design conditions, losses were calculated with the racks assumed to be 25 percent clogged with debris. Because clogging will interfere with downstream fish passage, it will be necessary for maintenance personnel to keep the racks relatively trash free. Therefore, 25 percent clogging was considered a reasonable maximum for design conditions.

f. Access Road. Conditions with flow over the access road were analyzed as weir flow using a weir coefficient of 2.6.

g. Water Surface Elevations. Flow conditions analyzed included 1,500 cfs, which is the design condition for stopping fish from moving upstream, 9,000 cfs -- the maximum non-damaging discharge from the dam, and 5,000 cfs -- used to set the access road elevation to prevent overtopping except under rare situations. Conditions examined included no barrier in the river, barrier in place but racks removed or down, and racks in place. Construction of the barrier will result in higher tailwaters at the end of the Townshend discharge conduit, but these increased depths will not be enough to affect discharge capacity. Higher tailwater depths will move the hydraulic jump at the end of the conduit a little further upstream. This will result in slightly higher water depths around the conduit and possible additional instability in surrounding soils; however, these effects are likely to be minor. Table 2 summarizes water surface elevations. It should be noted that although water surface elevations are given to one-tenth of a foot, they are probably accurate to plus or minus one-half foot.

(1) 1,500 CFS. With the racks 25 percent clogged with debris, there is a 0.3 foot drop in water surface elevation from 458.2 feet NGVD above the racks to 457.9 below. Tailwater elevation at the conduit exit is 458.5 feet, which is 4.5 above the outlet invert.

(2) 5,000 CFS. With the racks removed, there is a 0.3 foot drop in water surface elevation from 460.7 feet NGVD above to 460.4 below the racks. Tailwater elevation at the conduit exit is 461.5 feet which is 7.5 feet above the outlet invert. With the racks in place and 25 percent clogged with debris, the drop in water surface increases to 2.9 feet from elevation 463.1 above to 457.9 below the racks. Tailwater elevation at the conduit exit is 463.6 feet which is 9.6 feet above the outlet invert.

(3) 9,000 CFS. With barrier racks in place, and 25 percent clogged with debris, the upstream water surface elevation under maximum regulated reservoir release of 9,000 cfs is 465.5 feet NGVD. Tailwater elevation is 462.5 feet NGVD, giving a total drop in water surface across the racks of 3 feet. At the conduit exit, the water surface elevation is 466.1 which is 16.1 feet above the outlet invert. The operating plan for the barrier calls for racks to be removed during flows of 5,000 cfs or greater. With the racks removed, water level during maximum controlled releases would

RATING CURVE FOR WEST RIVER 618 FEET DOWNSTREAM FROM TOWNSHEND DAM CONDUIT OUTLET

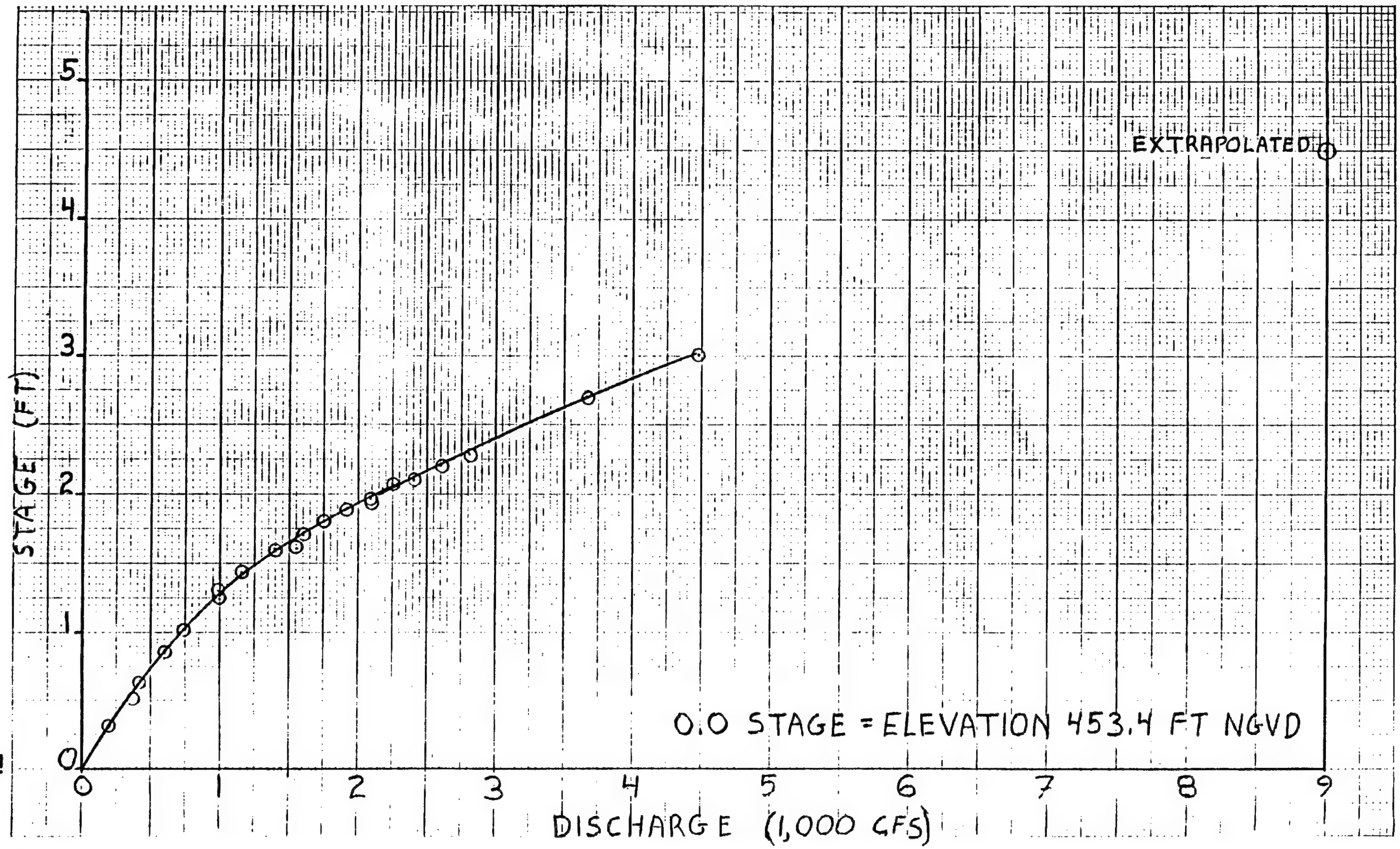


Figure 3

TABLE 2

TOWNSHEND LAKE FISH BARRIER
VELOCITIES AND WATER SURFACE ELEVATIONS

Flow (cfs)	HGL* Below Barrier (ft)	Velocity Below Barrier (fps)	HGL Above Barrier (ft)	Velocity Above Barrier (fps)	Tailwater at Conduit Outlet (ft)	Tailwater Above Conduit Outlet Invert (ft)
Natural Conditions						
1,500	457.4**	4.0	457.4	4.0	457.8	3.8
5,000	460.4	6.4	460.4	6.4	461.3	7.3
9,000	462.8	7.6	462.8	7.6	463.8	9.8
Rack Removed						
5,000	460.4	6.8	460.7	5.7	461.5	7.5
9,000	462.5	9.3	463.4	6.8	464.4	10.4
Rack in Place and 25 Percent Clogged with Debris						
1,500	457.9	3.4	458.2	2.7	458.5	4.5
5,000	460.4	6.8***	463.1	4.3	463.6	9.6
9,000	462.5	9.3****	465.5	6.2	466.1	12.1

*HGL = Hydraulic Gradeline, i.e. Water Surface Elevation.
**Although elevations are given to 0.1 ft, they are probably no more accurate than plus or minus 0.5 ft.
***If critical depth occurs, maximum velocities would be 11.5 fps.
****If critical depth occurs, maximum velocities would be 13 fps.

be about elevation 462.5 feet in the vicinity of the fish trapping facility. For conditions with 9,000 cfs and the racks in place, the access road is overtopped by about 2 feet. For conditions with 9,000 cfs and the racks removed, the road is not overtopped, but freeboard is negligible.

(4) Natural. Under natural conditions, i.e., before construction of the fish trap and barrier, water surface elevations in the vicinity of the barrier ranged from 457.4 for 1,500 cfs to 462.8 for 9,000 cfs. Tailwater above the conduit outlet invert ranged from 3.8 feet at 1,500 cfs to 9.8 feet at 9,000 cfs.

4. HYDRAULICS OF DOWNSTREAM PASSAGE FACILITIES

a. General. Downstream passage will be achieved by temporarily lowering Ball Mountain Lake during the spring to a 25-foot stage, and maintaining Townshend Lake at its normal 21-foot stage by use of the existing weir (plates B-2 through 4 show outlet works profiles at these dams). A small plunge pool will be constructed at Townshend Lake to improve fish survival during downstream passage. It may also be necessary to install an automatic gate at Ball Mountain Lake since manual control of the large flood control gates to maintain a 25-foot pool is very labor intensive and not very accurate. The following paragraphs describe the hydraulic analyses of these features.

b. Ball Mountain Lake

(1) General. The normal spring and summer pool at Ball Mountain Lake is 65 feet deep and controlled by operation of the flood control gates. During winter the pool is lowered to 25 feet deep. The 65-foot pool is a big obstacle to downstream fish passage; not only is it unlikely the fish would dive 65 feet to try to get through the gates, it is likely the abrupt pressure change encountered in passing through the gate would be fatal. There is no tailwater on the gates and the fish would be going from a pressure of 65 feet of water immediately upstream of the gate to atmospheric pressure immediately downstream. This problem is being addressed by a plan to lower Ball Mountain Lake to a depth of 25 feet during the smolt migration season. In the spring of 1990, a test release of radio-tagged smolts showed they could negotiate a 25-foot pool at Ball Mountain Lake.

(2) Automatic Gate. Due to the flashy nature of the watershed and narrow V-like valley immediately behind Ball Mountain Dam, the pool tends to rise and fall very quickly following runoff events. Consequently, manual operation of

the flood control gates to maintain a 25-foot pool is very labor intensive. Installation of an automatic gate is planned to maintain the pool at the 25-foot stage during the downstream migration period. This automatic gate would not be used to maintain the normal summer 65-foot pool.

c. Townshend Lake. In order to facilitate downstream passage of migrating salmon smolts through Townshend Lake Dam, USFWS personnel recommended cutting a notch in the weir in front of the center gate, and creating a plunge pool below the weir.

(1) Weir Notch. In order to provide a greater attraction velocity to draw fish to the weir, and provide a greater depth of flow over the weir to ease the smolt's downstream passage, USFWS personnel recommended that a notch be cut in the existing concrete weir at Townshend Dam. The desirable size for this notch was not specified; however, Mr. Michael Penko, of NED's Impact Analysis Division, recommended a depth of 6 inches to a foot. A larger notch would concentrate flow and more effectively attract smolts but would tend to lower lake levels during low flows. Consequently, in considering the optimum notch size, performance in passing fish was balanced against drawdown of the lake.

(2) Existing Weir. The existing weir at Townshend Dam is a box-inlet structure 18 feet in width on the end and 20.5 feet in length on the sides. Walls are 3-foot thick concrete, giving clear overflow lengths of 12 feet on the end and 17.5 on the sides for a total of 47 feet. Top of weir is at elevation 478 feet, NGVD. Using the standard weir formula, and Brater and King's Handbook of Hydraulics, table 5-3 to estimate a broad-crest weir coefficient of 2.4, minimum daily average flows had calculated depths of 1 to 3 inches over the weir, and minimum monthly average flows had depths of 4 to 7 inches.

(3) Notch Hydraulics. For a 1 foot by 1 foot notch, the estimated flow with the lake at elevation 478 is 3 cfs as computed by the broad-crested weir formula with a weir coefficient of 2.65. This is less than the minimum daily average flow of 7 cfs; consequently, such a notch would not significantly lower the recreation pool even during low flow events. Table 3 shows weir capacity with and without the notch. The effect of the notch on the weir rating curve for large flows is insignificant.

TABLE 3

WEIR HYDRAULICS WITH AND WITHOUT 1 BY 1 FOOT NOTCH

Lake Level	Existing Weir Q (cfs)	Notched Weir Notch Q (cfs)	Notched Weir Weir Q (cfs)	Notched Weir Total Q (cfs)
477	0	0	0	0
478	0	3	0	3
479	157	8	153	161
480	443	15	433	448
481	813	25	796	821
482	1250	37	1230	1270
483	1750	49	1710	1760
484	2300	62	2250	2310
485	2900	75	2840	2920

(4) Notch Location and Size. The obvious location for the notch would be the center of the end wall of the weir; however, it would work well at any location on the weir. Calculations show that if the notch is located on a side wall the stream of water will not hit the opposite wall. Although a 1 foot wide notch is recommended, a wider notch could be tolerated. The notch could be up to 3 feet wide and have minimal impact on recreation pool level even during low flow periods. A 3-foot wide notch cut 1-foot deep would discharge 8 cfs with the lake at weir crest elevation 478, which is slightly more than the average daily low flow of 7 cfs. Consequently, a 3-foot wide notch would have minimal impact on lake levels. These points are brought up because of reports that concrete on parts of the weir could be deteriorating. It might be possible to create the notch by cutting out some deterioration.

(5) Gate Leakage. Leakage around the gates, even when fully closed, is in the order of tens of cubic feet per second. Consequently, during low flow conditions, velocities approaching the weir surface and depths of flow over it are much lower than they should be. During very low flow conditions the only releases from the lake are from gate leakage. For attracting fish to the weir and providing a safe depth for passage over it, stopping leakage at the gates might be more effective than cutting a notch. However, the best of all worlds would be to cut the notch and stop the leakage. In the meantime, cutting a notch would provide some flow over

the weir during low flow conditions when the lake drops below elevation 478 due to gate leakage. Data on leakage rates are insufficient to estimate how often the pool would be below the bottom of the notch and prevent all downstream fish passage.

(6) Plunge Pool. Elevation of the box-inlet weir crest is 478 feet NGVD, and conduit invert at the base of the weir is 457 feet, making a 21-foot drop. In order to cushion the drop onto the concrete, a plunge pool about 3 feet deep was recommended by USFWS personnel.

(7) Previous Experience. In the springs of 1990 and 1991, Mr. Larry McLaughlin, Townshend Lake project manager, built a temporary plunge pool by placing nine 4 by 4 timbers in the emergency gate slot. This slot is 20 feet upstream from the main gate and 24 feet downstream from the box-inlet weir. Timbers were lowered one at a time, bolted on a threaded rod, and braced so they would remain in place. The top timber cracked one year when a heavy log went over the weir; however, there were no problems the second year. Timbers stayed in place in spite of flow so high the weir was submerged. In Mr. McLaughlin's opinion, this scheme worked well and was not an excessive amount of work, requiring only 2 hours for installation and 1 hour for removal. The only real disadvantage was the need to lower the lake below weir crest.

(8) Recommended Plan. The recommended plan for creating a plunge pool without needing to lower the lake would be to construct a frame the size of the emergency gate, about 11 feet wide and 12 feet high. The bottom 3 feet of this frame would be solid, but the remainder would be open except for a cross piece on top. The frame could be lowered and removed by using the crane at the project. Due to the need of bringing in a compressor to operate the crane, Mr. McLaughlin estimated it would be about as much effort as installing the nine 4 by 4 timbers; however, as it would not require lowering the lake, the barrier could be installed and removed more quickly. If constructed of sufficient metal to prevent it from floating, the frame could be stored on the intake tower's lower platform when not in use.

(9) Effects of Barrier on Reservoir Releases. Installing a 3-foot barrier in the conduit downstream from the weir will have no effect on discharge capacity. At low flows, hydraulic control for the center gate is at the concrete weir; however, at higher flows it moves to the gate. The 3-foot barrier is too low to affect flow over the concrete weir. When flow backs up from the gate and submerges

the weir, there is enough opening above the barrier so it does not form a restriction in the entrance channel to the gate.

(10) <u>Cavitation Effects</u>. Turbulence created by the proposed barrier possibly could cause cavitation when high flows are released through the center gate. Consequently, when the barrier is in place it might be advisable to make large releases through the two outside gates. This would also reduce the chance the 3-foot barrier would be damaged by floating debris. Using only the outside gates for large releases should present no real problems as these gates have sufficient discharge capacity. Maximum nondamaging downstream channel is 9,000 cfs. With 2 gates fully open, combined discharge is 9,000 cfs at a lake level of 499 feet NGVD, at which level the lake is storing only 0.7 inch of runoff; consequently, this would be only a minor restriction on flood control operations. Each gate can release up to 7,800 cfs when fully open with the lake at spillway crest elevation 553 feet NGVD.

5. COFFERDAM

a. <u>General</u>. The barrier and fish trap will be constructed in two phases (see figures 4 and 5). During the first phase, a cofferdam will be built out from the left bank to enclose the first 72 feet of river where the barrier will be constructed. During the second phase, a cofferdam will be built from the right bank to enclose the fish trap area and remaining unconstructed barrier. Flow area for diversion of water during construction is very tight and using up to an inch of runoff storage at Ball Mountain and Townshend Lakes will be necessary to restrict discharges (The Reservoir Regulation Evaluation Appendix discusses construction storages at Ball Mountain and Townshend Lakes in detail including the rationale for using 1 inch of runoff storage). Although these lakes have capacity to allow complete control of the river during all but extreme events, there are disadvantages to storing more than an inch of runoff. Storing water at Townshend Lake to reduce flows during construction will cause the recreation area to be flooded out and possible damage to trees surrounding the lake. The Winhall recreation area at Ball Mountain Lake is well above the elevations that would be flooded by construction storages. However, there is the potential that trees will be killed if inundated too long during the growing season, and there may be small increases in turbidity and sedimentation in the lake due to sloughing and bank erosion caused by higher pool levels. Consequently, it is necessary to achieve a balance between size of the cofferdam and the amount of construction season lake storage.

Phase 1 Cofferdam Schematic

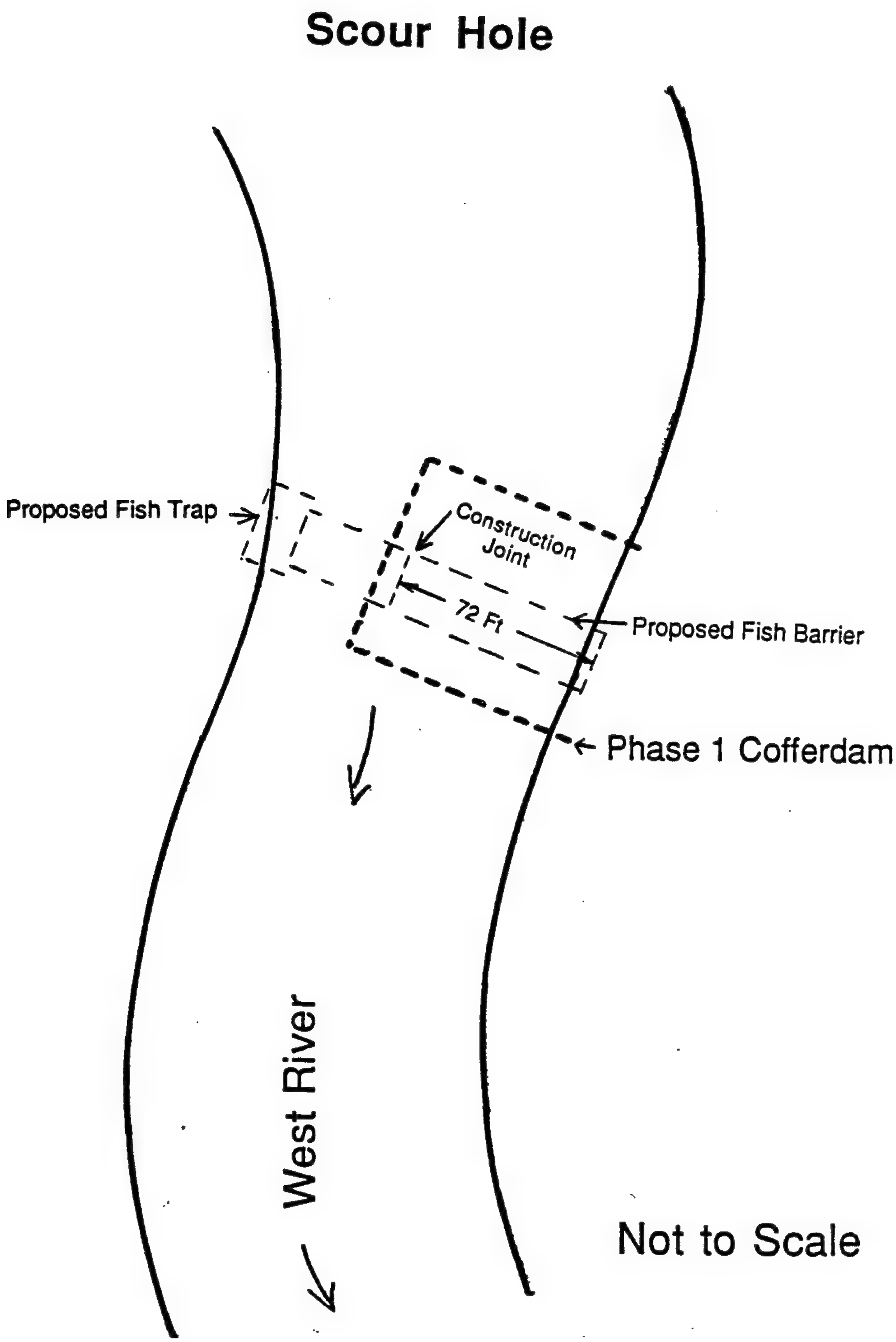


Figure 4

Phase 2 Cofferdam Schematic

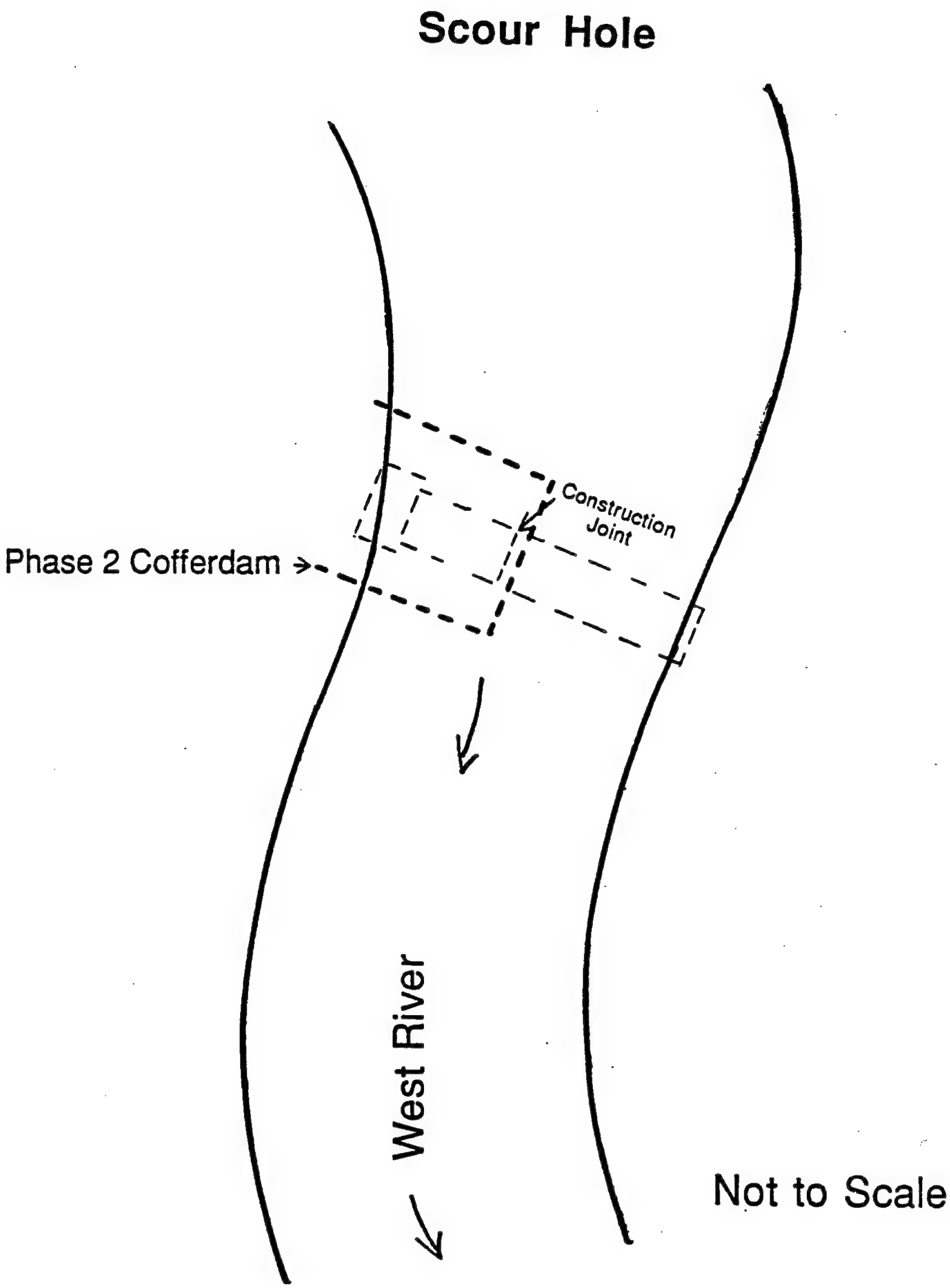


Figure 5

In order to maintain flood control capability, in no event will more than 1 inch of storage be allowed at each dam for diversion purposes.

b. Flows. Personnel from Reservoir Control Center and Operations Directorate have concluded that discharges can generally be restricted to 1,500 cfs during construction without unduly affecting pool levels or compromising flood control capability at Ball Mountain or Townshend Lakes. The instream construction period is expected to run from July through November. These flows would pass the cofferdams with maximum depths of about 6 feet. However, for safety reasons, while personnel are actually working in cofferdammed areas, there should be a minimum 1-1/2 feet of freeboard resulting in water depths no more than 4-1/2 feet which results in a discharge of no more than 1,000 cfs. This is a workable plan because mean monthly flow is less than 500 cfs during July, August and September. The expected schedule of releases would restrict discharges to 1,000 cfs during working hours and then open up to 1,500 cfs at night if water were stored at Ball Mountain or Townshend Lakes. The plan would be to provide storage equivalent to 1 inch of runoff from the upstream watershed at Ball Mountain Lake and 1 inch of the intervening storage between Ball Mountain and Townshend Lakes at Townshend. When flood control storage in Ball Mountain or Townshend exceeds 1 inch of runoff, the contractor would be notified that larger releases are going to be made. One inch of runoff at Ball Mountain Lake is equivalent to 9,200 acre-feet and would raise the pool about 90 feet from stage 25 to stage 115 feet. At Townshend Lake, 1 inch of runoff from the watershed not including Ball Mountain's is equivalent to 5,650 acre-feet of storage, and would raise the normal pool level 26 feet to a maximum depth of 47 feet.

c. Phase One. During the first phase, a cofferdam will be built from the left bank and enclose the first 72 feet of West River channel where the barrier will be constructed. Sheet piling will be driven at the river side of the cofferdam, and upstream and downstream ends of the cofferdam will be built from earth fill and rock protection. The access road to the right bank will not be built up to allow the area to be used for overflows. For flows of 1,500 cfs, maximum water surface elevations in the vicinity of the cofferdam would be 458.8 feet and maximum energy grade lines would be 458.9 feet NGVD. These correspond to heights of 5.8 and 5.9 feet above the channel invert elevation of 453 feet. Flows would be near critical depth and velocities past the cofferdam would be in the range of 5 to 7 fps. Table 4 contains summaries of water surface elevations and velocities for the left bank cofferdam with flows of 1,000 and 1,500

TABLE 4

WEST RIVER FISH PASSAGE STUDY
SUMMARY OF COFFERDAM ANALYSES USING HEC2
(Elevations are in Feet NGVD)

		Left Bank Cofferdam			Natural Condition		Right Bank Cofferdam	
Sta	Flow (cfs)	HGL	EGL	V (fps)	HGL	EGL	HGL	EGL
440	1500*	455.8	456.9	8.5	455.8	456.9	455.8	456.9
410	1500	456.4	457.8	9.5	456.6	457.3	456.6	457.3
385**	1500	457.9	458.2	4.2	457.2	457.5	457.3	457.5
359**	1500	457.9	458.4	5.5	457.3	457.5	457.4	457.5
334**	1500	457.9	458.4	6.0	457.4	457.6	457.5	458.5
315**	1500	457.9	458.6	6.6	457.4	457.6	458.2	458.6
291**	1500	458.3	458.7	5.0	457.5	457.7	457.9	459.2
208**	1500	458.8	458.9	2.3	457.6	457.8	459.6	459.8
188	1500	458.8	458.9	2.5	457.6	457.8	459.8	459.8
440	1000	455.1	456.1	7.9	455.1	456.1	455.1	456.1
410	1000	455.7	456.8	8.5	455.7	456.5	455.7	456.5
385**	1000	456.9	457.1	4.0	456.5	456.7	456.6	456.7
359**	1000	456.9	457.3	5.0	456.6	456.8	456.6	456.7
334**	1000	456.9	457.3	5.1	456.7	456.8	456.3	457.1
315**	1000	456.9	457.4	5.6	456.7	456.9	456.7	457.4
291**	1000	457.2	457.5	4.3	456.8	456.9	457.5	458.2
208**	1000	457.6	457.7	2.0	456.9	457.0	458.5	458.7
188	1000	457.6	457.7	2.2	456.9	457.0	458.7	458.7
440	500	454.4	455.0	6.1	454.4	455.0	454.4	455.0
410	500	454.8	455.5	6.9	454.8	455.4	454.8	455.4
385**	500	455.6	455.8	4.0	455.5	455.7	455.6	455.7
359**	500	455.7	456.0	4.0	455.7	455.8	455.7	455.7
334**	500	455.8	456.0	3.7	455.8	455.8	455.7	456.2
315**	500	455.8	456.1	4.1	455.8	455.9	456.0	456.3
291**	500	456.0	456.2	3.1	455.9	455.9	456.5	456.9
208**	500	456.2	456.2	1.6	455.9	456.0	457.2	457.3
188	500	456.2	456.3	1.6	455.9	456.0	457.3	457.3

*Elevations are given in to the nearest 0.1 feet, but are probably accurate to only 0.5 feet.

**Cofferdam stations.

cfs. It should be noted that although water surface elevations are given to one-tenth of a foot, they are probably accurate to no more than plus or minus one-half foot.

d. Phase Two. During the second phase, a cofferdam will be built from the right bank to enclose the fish trap and remaining unconstructed barrier. Concrete blocks, Jersey barriers, and sandbags will be used to build a 6-foot high wall to close off the end of the cofferdam (i.e., parallel to river flow). The bottom course of blocks will be placed on the end section of the barrier slab completed during Phase 1. Upstream and downstream ends of the cofferdam will be constructed from earth fill and rock protection. For flows of 1,500 cfs, maximum water surface elevations in the vicinity of the cofferdam would be 459.6 feet and energy grade lines would be 459.9 feet NGVD. These correspond to heights of 5.6 and 5.8 feet above the barrier invert elevation of 454 feet. Table 4 contains summaries of water surface elevations for the right bank cofferdam with flows of 500, 1,000, and 1,500 cfs. It should be noted that although water surface elevations are given to one-tenth of a foot, they are probably accurate to no more than plus or minus one-half foot.

6. RIPRAP PROTECTION

a. General. Riprap protection is designed for the maximum expected flow of 9,000 cfs. Three types of riprap protection are required: (1) for transition from the concrete pad below the barrier to the streambed, (2) along the disturbed portions of the riverbanks, and (3) along the side of the access road.

b. Below Concrete Pad. Although the fish barrier racks are supposed to be removed for flows greater than 5,000 cfs, riprap protection is designed for a condition with a 9,000 cfs discharge and the racks in place. Under this condition, there is a differential between upstream and downstream water depths of 3.3 feet if the racks are 25 percent clogged with debris, and 5.3 feet with the racks 100 percent clogged. Assuming this difference in water depths is converted to velocity and added to downstream velocity, the resulting Froude number is 1.2 for the 100 percent clogged condition and 1.04 for 25 percent clogged. As these numbers are greater than 1.0, critical depth and a weak hydraulic jump could occur.

(1) Use of Riprap. Because critical depth and a hydraulic jump could occur below the racks, the justification for using riprap instead of a stilling basin should be examined. As explained in Design of Small Dams, 2nd Edition,

Section 206, "For Froude numbers from 1.0 up to about 1.7, the incoming flow is only slightly below critical depth, and the change from this low stage to the high stage flow is gradual and manifests itself only by a slightly ruffled water surface. . . . No special stilling basin is needed to still flows where the incoming flow Froude factor is less than 1.7." Due to weakness of the jump, use of stone riprap below the barrier is justified.

(2) Stone Size. Because flow goes through critical depth, the riprap should be sized using stilling basin criteria rather than streambank erosion criteria. This is in agreement with Draft EM 1110-2-1601, "Hydraulic Design of Flood Control Channels." The HEC-2 Water Surface Profiles program was used to compute critical depth conditions below the barrier. Results showed a channel velocity of 15.4 fps and maximum depth of 7.84 feet. Normal depth in the channel is 9.5 feet. Using Hydraulic Design Chart (HDC) 712-1, "Stone Stability, Velocity Vs Stone Diameter," a minimum D_{50} stone size of 3.4 feet was determined using the "High Turbulence" area plots.

(3) Apron Length. Required length of riprap apron can be estimated using techniques for computing stilling basin length. From EM 1110-2-1603, "Hydraulic Design of Spillways," page 7-2, length is given as equal to the pre-jump depth times a coefficient "K" times the Froude number to the 1.5 power. Table 7-1 in EM 1110-2-1603 gives "K" values ranging from 1.4 to 2.0. Because of the downstream backwater depth and weakness of the jump, a "K" of 1.4 seems reasonable; however, to be conservative, a "K" of "2" was used. For a depth of 7.84 feet, Froude number of 1.2, and "K" of "2"; the resulting apron length is 20 feet. Because there is an 18-foot concrete apron downstream from the bar racks, only a few feet of 3.4-foot stone would be required beyond the concrete. Alternatively, the concrete apron could be extended another 2 feet.

c. Transition Riprap. Stone for the transition between the 3.4-foot stone and the unprotected channel bottom was sized using HDC 712-1 "Low Turbulence" plots. Twenty feet downstream from the barrier, computed channel velocity was 7.7 fps. HDC 712-1 shows a 0.6 foot D_{50} stone diameter would be effective for flows up to 9 fps. Therefore, this stone diameter would provide excellent protection. The estimated apron length of 0.6-foot stone is 20 feet. A 20-foot apron of 0.6-foot stone is also recommended for the upstream side of the fish barrier.

d. Channel Side Slope Riprap. Channel side slopes

should be protected for 20 feet upstream and 40 feet downstream from the fish barrier. Additional lengths of channel that are disturbed during construction should also be protected. Riprap should be carried up the side slopes to protect the 9,000 cfs energy gradeline level. Conditions with 5,000 and 1,500 cfs were checked to confirm that the 9,000 cfs condition produced the most severe problems for riprap at the channel bottom.

(1) <u>Downstream Side Slope Protection</u>. The slope of the energy grade line from the downstream edge of the 3.4-foot diameter stone to the next downstream station is 0.32 percent. Average depth of flow is 9.75 feet. Assuming 1:2 side slopes, the required minimum D_{50} stone size is 0.6 foot. For areas downstream from the barrier, the riprap protection elevation would be 464 feet NGVD.

(2) <u>Upstream Side Slope Protection</u>. The slope of the energy grade line from the upstream edge of the concrete pad to the next upstream station is 0.1 percent. Average depth is 11.4 feet. Assuming 1:2 side slopes, the required minimum D_{50} stone size is 0.25 foot. For areas upstream from the barrier, the riprap protection elevation would be 467 feet NGVD with fish barrier racks in place, and 465 feet with racks removed.

e. <u>Access Road Protection</u>. The access road to the fish trap is set at elevation 463.6 feet NGVD which is about 2 feet higher than the existing ground. At this elevation the road will not be overtopped by any condition short of a 9,000 cfs discharge occurring with the fish barrier racks in place. Because the racks are supposed to be removed for flows greater than 5,000 cfs, it may not be considered necessary to use riprap protection on sides of the road. Furthermore, it may be cheaper to repair the road in the rare event it is overtopped than to provide riprap protection. If protection is desired, the 0.6 foot D_{50} stone diameter used for channel protection downstream from the barrier would provide very effective protection for the downstream side of the road. Similarly, the 0.25 D_{50} stone used for channel protection upstream from the barrier would provide very effective protection for the upstream side of the road.

7. SCOUR HOLE AT TOWNSHEND LAKE DAM

a. <u>General</u>. There is a large scour hole below the outlet conduit to Townshend Dam and its presence must be considered in the fish barrier and trap design. The hole, about 140 feet in length and up to 16 feet deep, was created by high discharges during the April 1987 floods.

b. Original Design. In the June 1956 Hydraulics Design Memo No. 1, a stilling basin was recommended because of the erosive effects of 63 fps velocities associated with the maximum design discharge of 11,000 cfs. Channel capacity at that time was taken as 11,000 cfs; later, nondamaging channel capacity was determined to be 9,000 cfs. Bedrock was described as a mica schist that was jointed and, when subjected to high velocity flows, could be torn out in slabs or blocks. A stilling basin was recommended to lessen scouring on the channel bottom, prevent uncontrolled erosion below the dam, and reduce the possibility of breaking up the rock formation.

c. Modified Design. In the February 1957 Supplement to DM No. 1, the stilling basin was eliminated to save money. Justification was that the bedrock was a sericite schist that had resisted action of the river for many centuries at other locations.

d. April 1987 Flood. The largest flood since Townshend Lake was completed occurred in April 1987. During this event, discharges of 9,000 cfs and greater were recorded on three days from the 6th through the 8th, and flows over 8,000 cfs were recorded through the 13th. According to records in NED's Reservoir Control Center, maximum flow was 10,850 cfs. Spillway discharge occurred on four days; however, spillway discharges bypassed the scour hole. Outlet discharges eroded the left and right banks and bedrock on the channel bottom immediately below the outlet conduit.

e. Potential Growth of Scour Hole. Using hydraulic design criteria chart 722-4, a design flow of 9,000 cfs from a 20.5-foot diameter conduit lasting 5.5 days (a condition approximating that which occurred during the April 1987 flood), could scour a 460 foot long hole in alluvial material. Conditions below Townshend Dam, as revealed by 1991 borings, consist of unconsolidated gravels, cobbles, and boulders overlying deposits of sand, gravel, and silt which overlie bedrock; this would produce different scour patterns than those for which chart 722-4 was developed. However, the chart indicates significant erosion beyond the existing scour hole is possible.

f. OCE and WES Involvement. On 10 October 1991, NED hydraulics personnel met with Mr. Tom Munsey of OCE to examine the scour hole and site of the proposed fish trap and barrier. His opinion, and those of NED personnel, were that the proposed structures were far enough downstream so as not to be threatened by the scour hole. This conclusion was reinforced by Mr. Glenn Pickering, Chief, Hydraulic Structures Branch at the Waterways Experiment Station (WES).

Mr. Pickering reviewed plans and maps forwarded to him at WES and concluded that the scour hole would not reach the barrier; however, he recommended that it be monitored. On this basis, the proposed location of the fish barrier and trap was considered far enough downstream to be stable.

8. WATER QUALITY

a. General. The West River watershed consists of largely undeveloped land with no significant point-source discharges. Stream channels tend to be steep causing rapid runoff with turbulent mixing and good aeration. Consequently, water quality in the West River would be expected to be good and generally meet or exceed Vermont class B criteria. Data collected by the State of Vermont and the Corps of Engineers confirm this. A study by the New England Division in November 1987, entitled "Atlantic Salmon Suitability at Townshend, Vermont" concluded that water quality below Townshend Dam was near optimal for salmon survival. This is in agreement with findings by the USFWS which conclude that the West River is one of the best in Vermont for salmon habitat and spawning.

b. Water Quality Classification. The West River and its tributaries are designated class B waters by the Vermont Water Resources Board. Such a designation means the waters should be managed to achieve and maintain a high quality habitat for aquatic biota, fish and wildlife.

c. Project Effects. The effects of salmon passage facilities and operations at Ball Mountain and Townshend Lakes on water quality will be minimal. Fish trapping and transportation facilities below Townshend Lake will have no discernable effects on water quality beyond short term turbidity during initial construction. However, this would be kept to a minimum through silt barriers and other erosion control methods. Similarly, providing downstream passage at Townshend Lake will have no effect on water quality as it will not involve any change from existing operating conditions. It is lowering the pool at Ball Mountain Lake to provide downstream passage, and fluctuations in the pools at Ball Mountain and Townshend during construction that have long-term potential to affect water quality.

d. Ball Mountain Lake. This project is currently operated to maintain a minimum summer recreation pool at a 65-foot stage and a winter conservation pool at 25 feet. Because a 65-foot deep pool was thought to be a serious barrier to seaward migrating salmon, it was experimentally lowered to the 25-foot stage during May 1990. While the pool was down,

radio-tagged salmon smolts were released to confirm their ability to get past the dam under these conditions.

e. Mud Flats. Lowering the pool to the 25-foot stage, exposes large areas of unsightly mud flats. These flats form from fine sediments which settle out in the quiescent lake environment during the summer. Exposing these sediments to view also exposes them to potential erosion and increases in turbidity in the river. Although, these mud flats are exposed during the winter without significant effects on turturbidity, the soils are frozen at that time of year which greatly reduces their susceptibility to erosion.

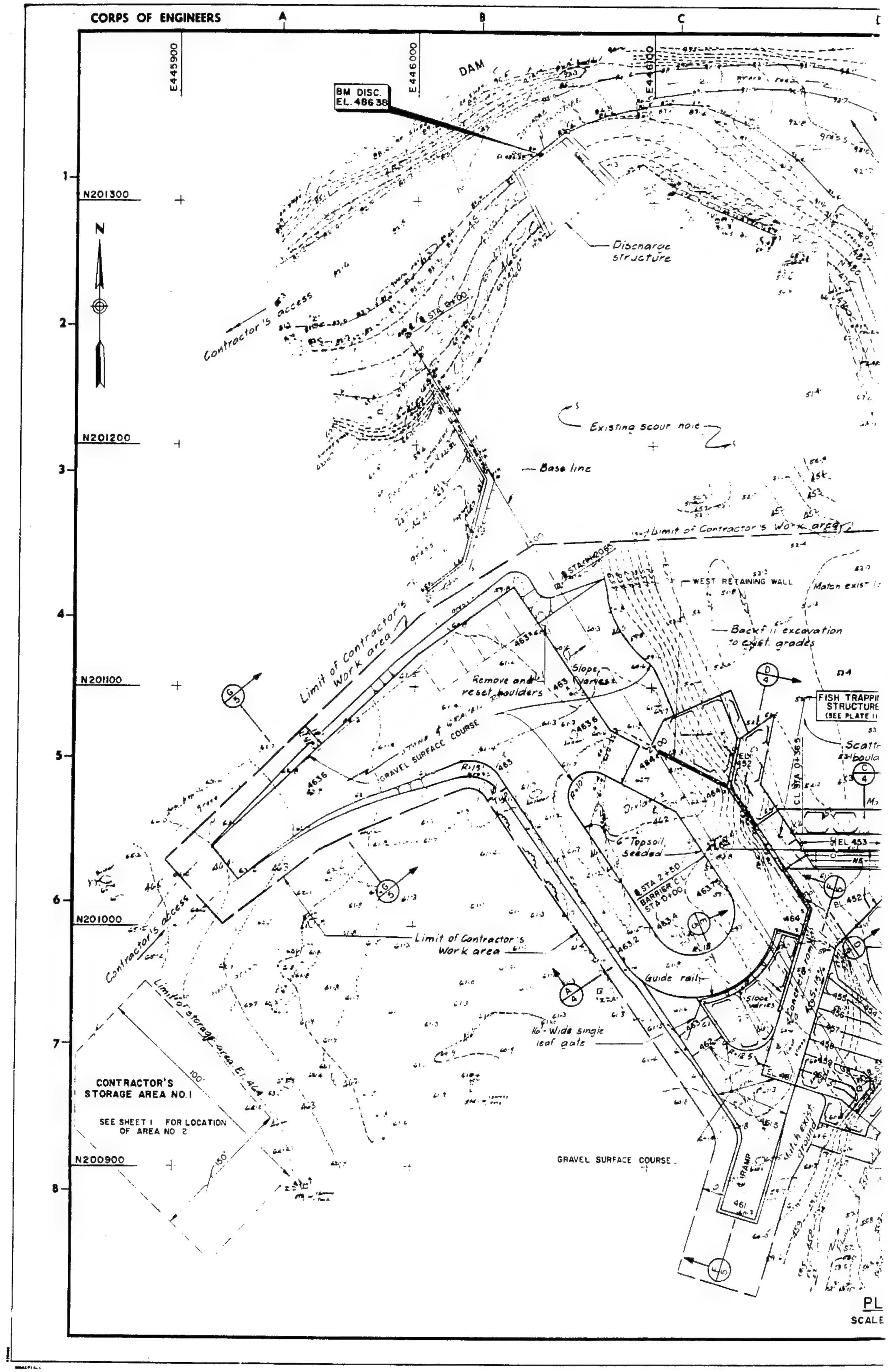
f. Turbidity Effects. While the pool was lowered during May 1990, water samples were collected from locations above and below Ball Mountain Lake and analyzed for turbidity. Additionally, project and basin managers visually noted turbidity levels in the West River and its tributaries. Results of these observations and analyses showed no increase in turbidity in the river during the period the pool was drawn down, even following heavy rainstorms. Cohesion in the mud flats and settling in the remaining 25-foot pool were enough to prevent noticeable turbidity increases. It is likely that when the pool was first brought down to the 25-foot stage there was a brief increase in turbidity; however, no observers were around to document it. That brief turbidity increase would not be enough to have a significant effect on water quality in the West River.

g. Refilling the Pool. If the Ball Mountain pool is lowered to 25 feet in the spring for downstream salmon passage, it may be desirable to refill it after migration, probably in June, to the normal 65-foot summer pool. With normal West River flows this would not be a problem or take long. However, during times of very low flows, such as drought periods, refilling the pool could take months, resulting in a prolonged period of an unsightly "bathtub ring" in the reservoir and potential siltation problems. How long the pool would be drawn down would depend on the streamflow and minimum release required to maintain downstream aquatic habitat. The pool could only be filled by project inflow in excess of the minimum release, and it is likely that during a drought the minimum desired release will be equal to the project inflow. The actual schedule of minimum releases during the period when the pool is being refilled would have to be worked out by the Corps in consultation with the U.S. Fish and Wildlife Service and the Vermont Department of Fish and Game.

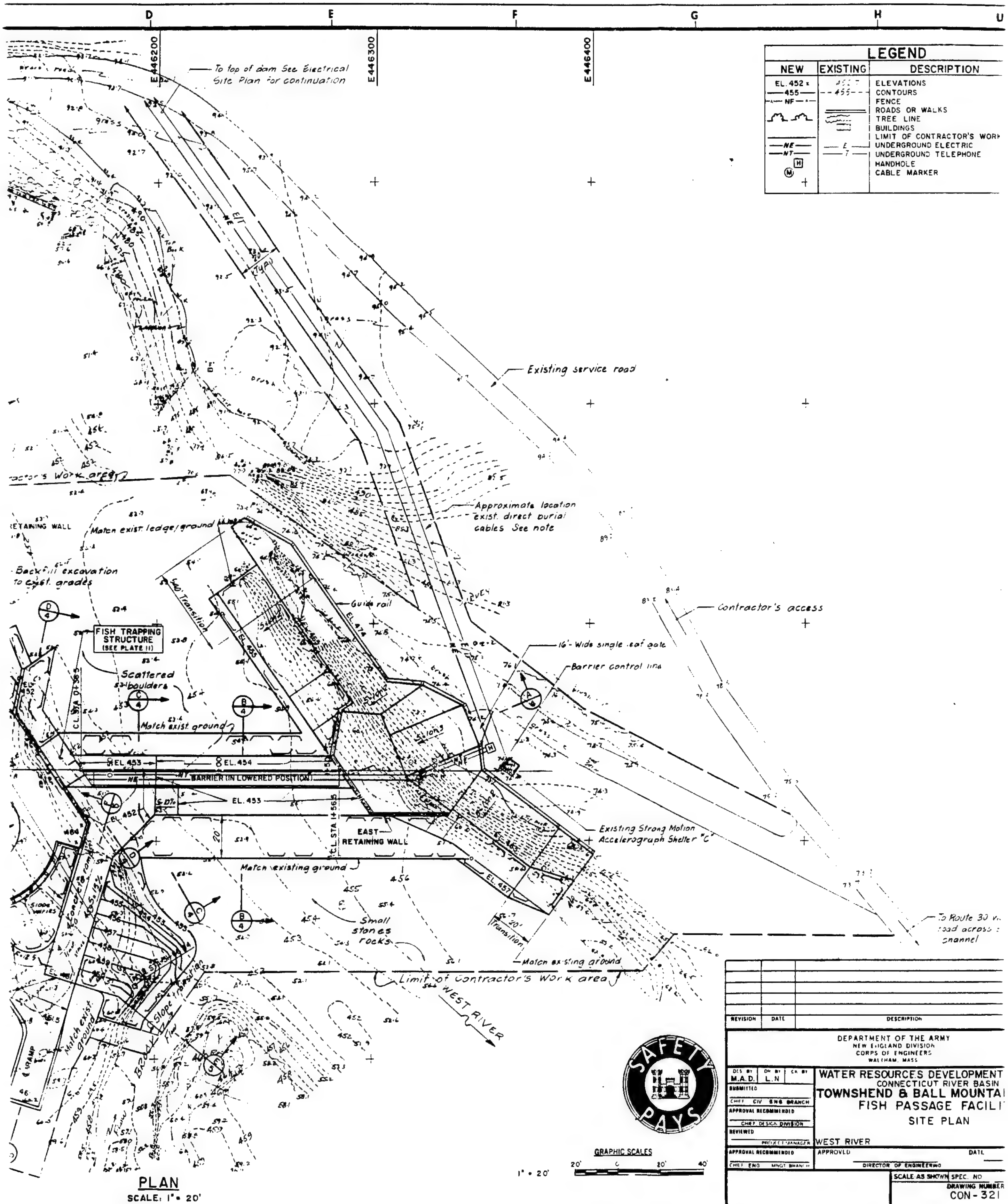
h. Construction Storages. Restricting discharges from Ball Mountain and Townshend Lakes during construction to

prevent overtopping of the cofferdams will result in greater and longer increases in pool level than normal. This could cause leaching of organic acids, nutrients, and BOD from the forest litter. In turn these could cause increased color, reduced oxygen levels, and a greater susceptibility to algae blooms in the lake. However, these effects would be localized, minor, and transient. On the whole, water quality effects would not be significant; however, it is possible that increased pool levels during the summer could result in greater tree mortalities.

i. Conclusions. High water quality in the West River at Ball Mountain and Townshend Lakes provides excellent habitat for Atlantic salmon. Proposed upstream and downstream fish passage facilities and reservoir regulation plans will have no significant effect on water quality in the West River. However, during drought periods the spring drawdown of Ball Mountain Lake could result in an unsightly bathtub ring persisting through the summer and even into fall, and increased summer pool levels at Ball Mountain and Townshend Lakes could cause greater tree mortalities around the lakes.


CORPS OF ENGINEERS
A
B
C
E445900
E446000
E446100
DAM
BM DISC.
EL. 486.38
N201300
N201200
N201100
N201000
N200900
1
2
3
4
5
6
7
8
N
Contractor's access
Discharge structure
Existing scour hole
Base line
Limit of Contractor's Work area
WEST RETAINING WALL
Match exist
Backfill excavation to exist. grades
Slope varies
Remove and reset boulders
FISH TRAPPING STRUCTURE (SEE PLATE
GRAVEL SURFACE COURSE
6" Topsoil, seeded
STA 2+50 BARRIER C.L. STA 0+00
Limit of Contractor's Work area
Guide rail
16' Wide single leaf gate
Slope varies
Concrete ramp
Match exist. ground
Limit of storage area El. 464
100'
150'
CONTRACTOR'S STORAGE AREA NO. 1
SEE SHEET 1 FOR LOCATION OF AREA NO. 2
GRAVEL SURFACE COURSE
RAMP
EL 453
EL 452
PL
SCALE

0



LEGEND

NEW	EXISTING	DESCRIPTION
EL. 452 x	452	ELEVATIONS
455	455	CONTOURS
NF		FENCE
		ROADS OR WALKS
		TREE LINE
		BUILDINGS
		LIMIT OF CONTRACTOR'S WORK
NE	E	UNDERGROUND ELECTRIC
NT	T	UNDERGROUND TELEPHONE
H		HANDHOLE
M		CABLE MARKER

REVISION	DATE	DESCRIPTION

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

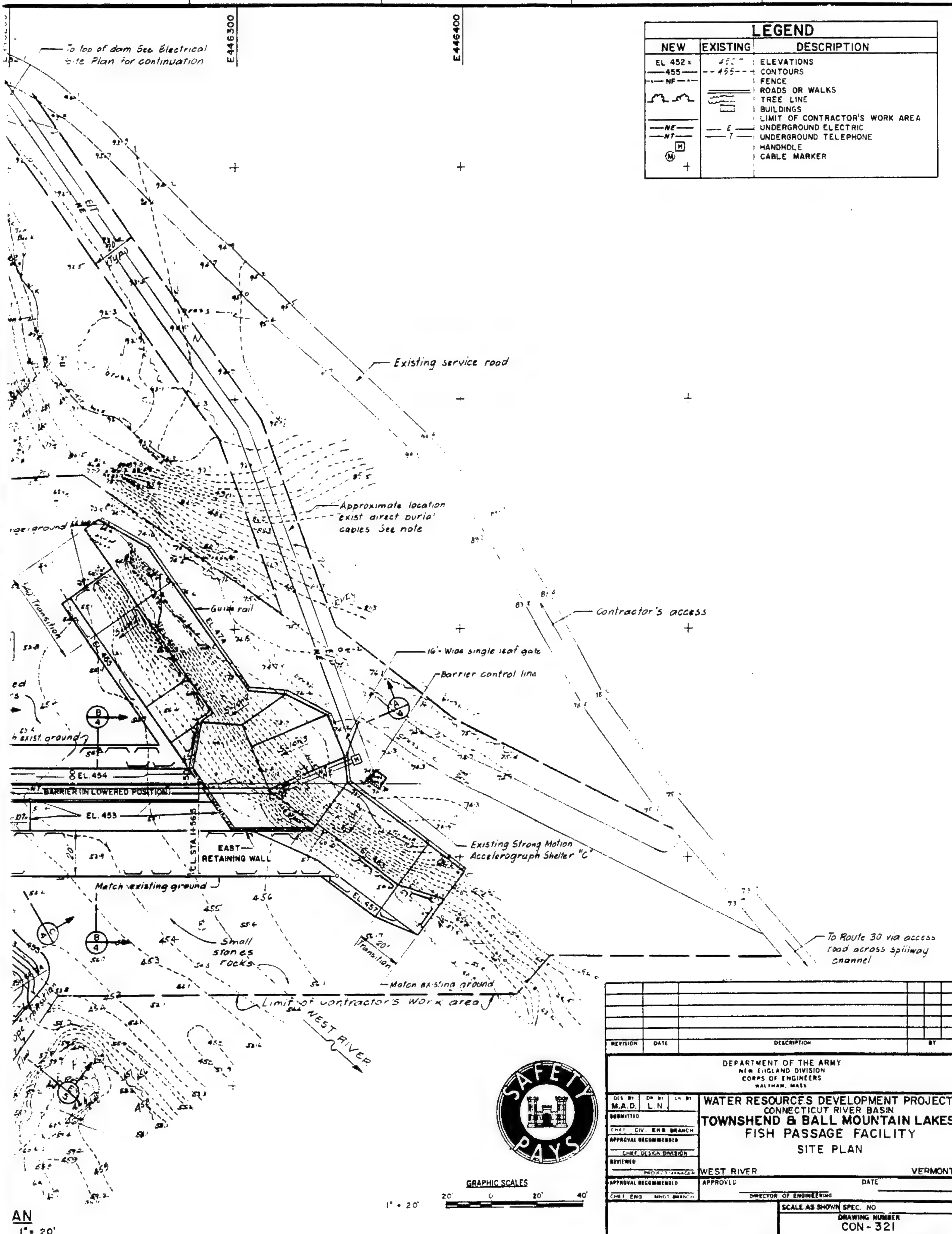
DES BY: M.A.D. DR BY: L.N. CK BY:
SUBMITTED
CHIEF CIV ENG BRANCH
APPROVAL RECOMMENDED
CHIEF DESIGN DIVISION
REVIEWED
PROJECT MANAGER
APPROVAL RECOMMENDED
CHIEF ENG MNGT BRANCH

WATER RESOURCES DEVELOPMENT
CONNECTICUT RIVER BASIN
TOWNSHEND & BALL MOUNTAI
FISH PASSAGE FACILI
SITE PLAN
WEST RIVER
APPROVED DATE
DIRECTOR OF ENGINEERING
SCALE AS SHOWN SPEC. NO.
DRAWING NUMBER CON-321

Pl

2

U. S. ARMY



LEGEND

NEW	EXISTING	DESCRIPTION
EL 452 x	452	ELEVATIONS
—455—	- - 455 - -	CONTOURS
—NF—		FENCE
		ROADS OR WALKS
		TREE LINE
		BUILDINGS
		LIMIT OF CONTRACTOR'S WORK AREA
—NE—	— E —	UNDERGROUND ELECTRIC
—NT—	— T —	UNDERGROUND TELEPHONE
H		HANDHOLE
M		CABLE MARKER

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY M.A.D. | DR. BY L.N. | CK. BY

SUBMITTED

CHIEF, CIV. ENG. BRANCH

APPROVAL RECOMMENDED

CHIEF, DESIGN DIVISION

REVIEWED

PROJECT MANAGER

APPROVAL RECOMMENDED

CHIEF, ENG. MNGT. BRANCH

WATER RESOURCES DEVELOPMENT PROJECT
CONNECTICUT RIVER BASIN
TOWNSHEND & BALL MOUNTAIN LAKES
FISH PASSAGE FACILITY
SITE PLAN

WEST RIVER VERMONT

APPROVED DATE

DIRECTOR OF ENGINEERING

SCALE: AS SHOWN | SPEC. NO.

DRAWING NUMBER
CON - 321

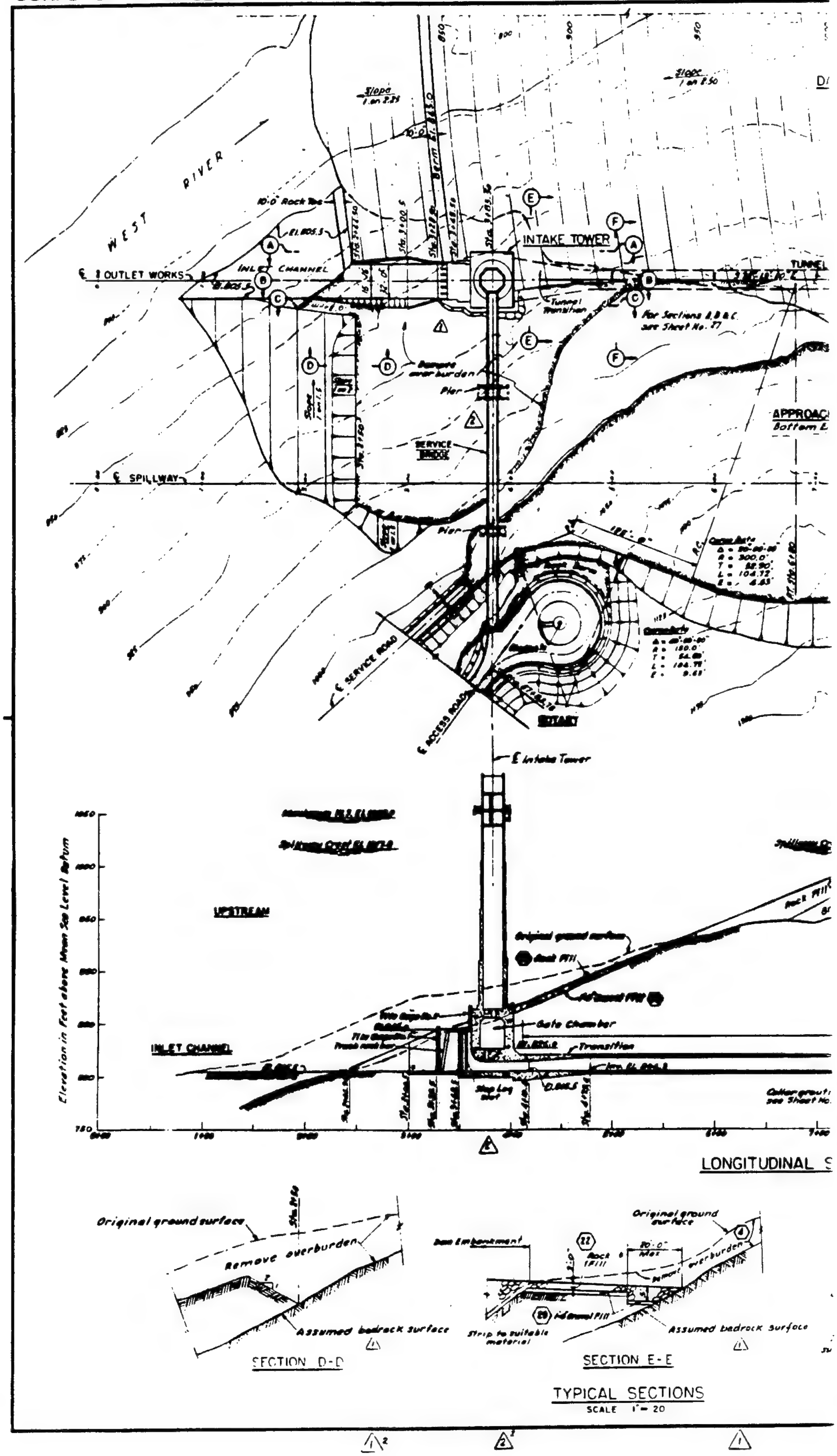
SHEET 3

AN
1" = 20'

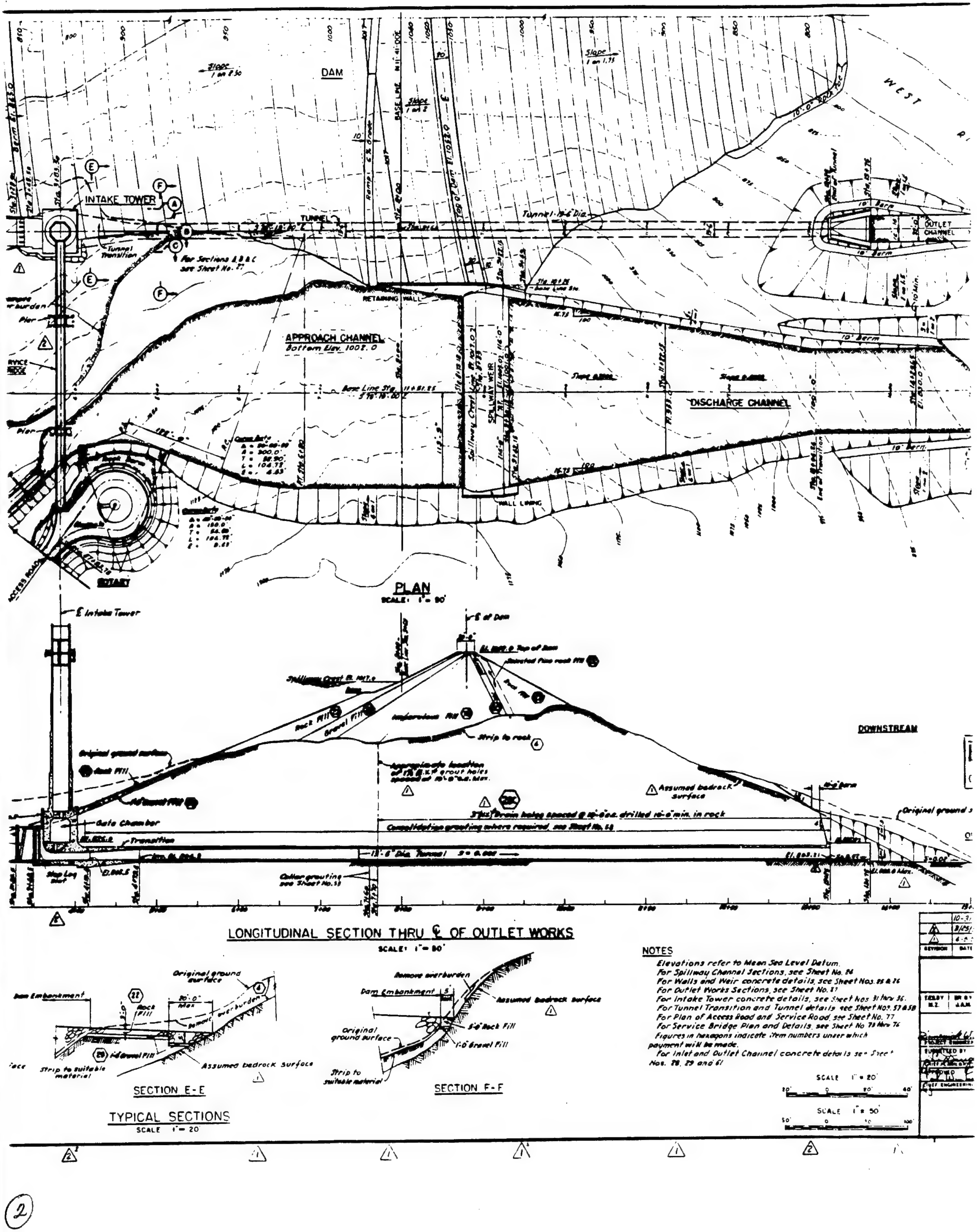
Plate B-1

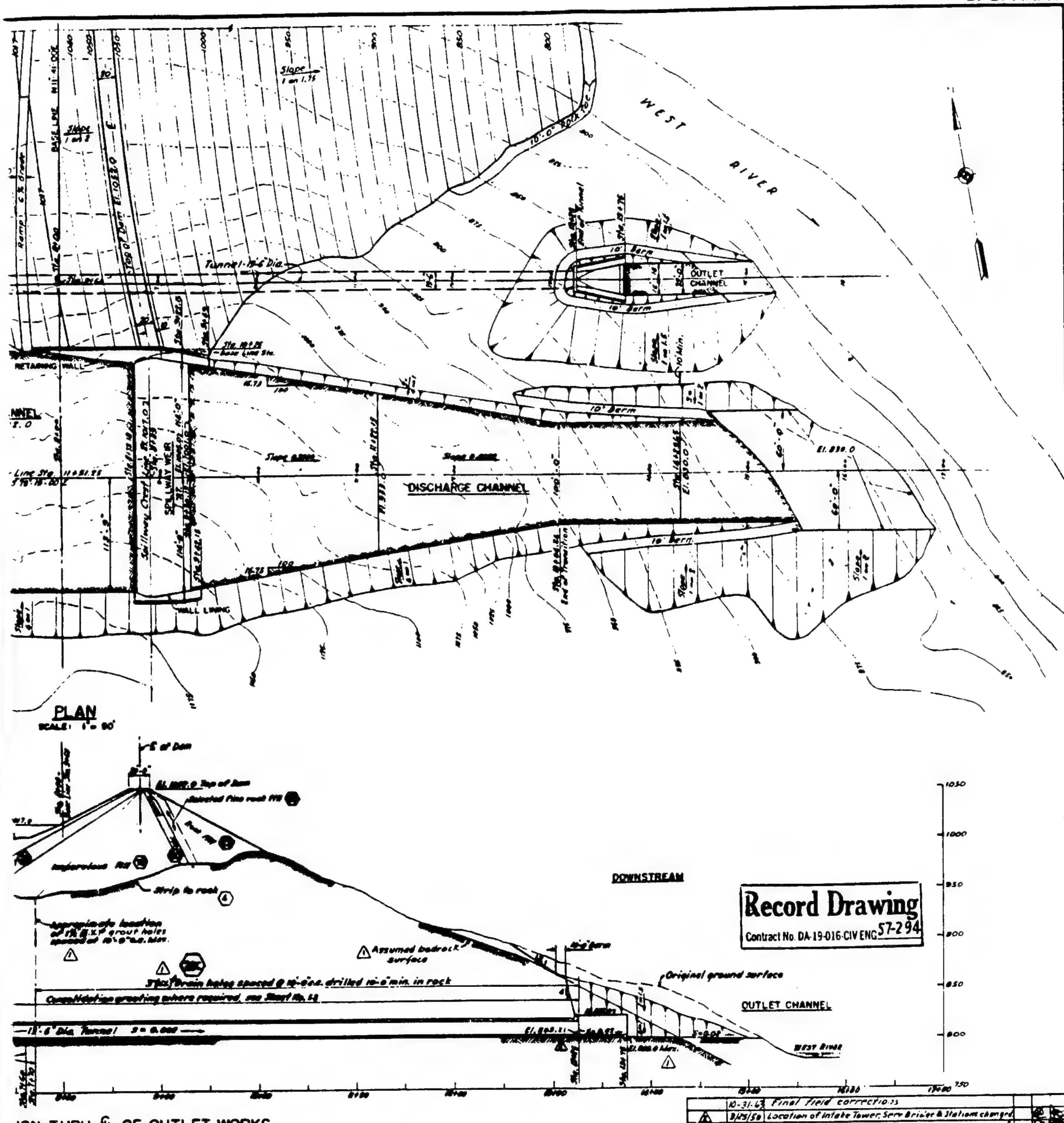
3

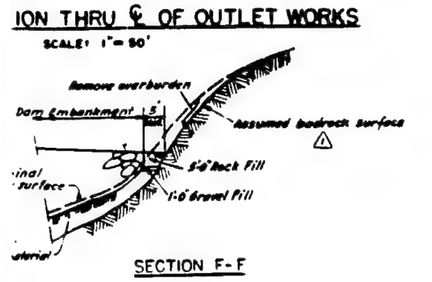
CORPS OF ENGINEERS



(1)


DAM
WEST
INTAKE TOWER
TUNNEL
Tunnel Transition
For Sections A, B & C see Sheet No. 57
Tunnel-13'-6" Dia.
OUTLET CHANNEL
10' Berm
RETAINING WALL
APPROACH CHANNEL
Bottom Elev. 1002.0
SPILLWAY WEIR
DISCHARGE CHANNEL
WALL LINING
ROTARY
ACCESS ROAD
PLAN
SCALE: 1" = 50'
℄ Intake Tower
℄ of Dam
Spillway Crest El. 1017.0
Rock Fill
Gravel Fill
Impervious Fill
Strip to rock
Original ground surface
Assumed bedrock surface
DOWNSTREAM
Gate Chamber
Transition
13'-6" Dia. Tunnel
Stop Log Slot
Collar grouting see Sheet No. 58
Consolidation grouting where required, see Sheet No. 58
LONGITUDINAL SECTION THRU ℄ OF OUTLET WORKS
SCALE: 1" = 50'
NOTES
Elevations refer to Mean Sea Level Datum.
For Spillway Channel Sections, see Sheet No. 24
For Walls and Weir concrete details, see Sheet Nos. 25 & 26
For Outlet Works Sections, see Sheet No. 57
For Intake Tower concrete details, see Sheet Nos. 31 thru 36.
For Tunnel Transition and Tunnel details, see Sheet Nos. 57 & 58
For Plan of Access Road and Service Road, see Sheet No. 77
For Service Bridge Plan and Details, see Sheet No. 73 thru 76
Figures in hexagons indicate item numbers under which payment will be made.
For Inlet and Outlet Channel concrete details see Sheet Nos. 28, 29 and 61
Dam Embankment
Rock Fill
Gravel Fill
Remove overburden
Strip to suitable material
Assumed bedrock surface
Original ground surface
5'-0" Rock Fill
1'-0" Gravel Fill
SECTION E-E
SECTION F-F
TYPICAL SECTIONS
SCALE 1" = 20'
SCALE 1" = 20'
SCALE 1" = 50'
2





NOTES

Elevations refer to Mean Sea Level Datum.
For Spillway Channel Sections, see Sheet No. 24
For Walls and Weir concrete details, see Sheet Nos 25 & 26
For Outlet Works Sections, see Sheet No. 27
For Intake Tower concrete details, see Sheet Nos 31 thru 36.
For Tunnel Transition and Tunnel details, see Sheet Nos. 57 & 58
For Plan of Access Road and Service Road, see Sheet No. 77
For Service Bridge Plan and Details, see Sheet No 73 thru 76
Figures in hexagons indicate item numbers under which payment will be made.
For Inlet and Outlet Channel concrete details see Sheet Nos. 28, 29 and 61

SCALE 1" = 20'

SCALE 1" = 50'

REVISION	DATE	DESCRIPTION	BY
	10-31-63	Final field corrections	
2	3/25/58	Location of Intake Tower, Serv Bridge & Stations changed	
1	4-5-57	Notes revised. Note added. Drain holes revised &c.	

CORPS OF ENGINEERS U S ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON MASS

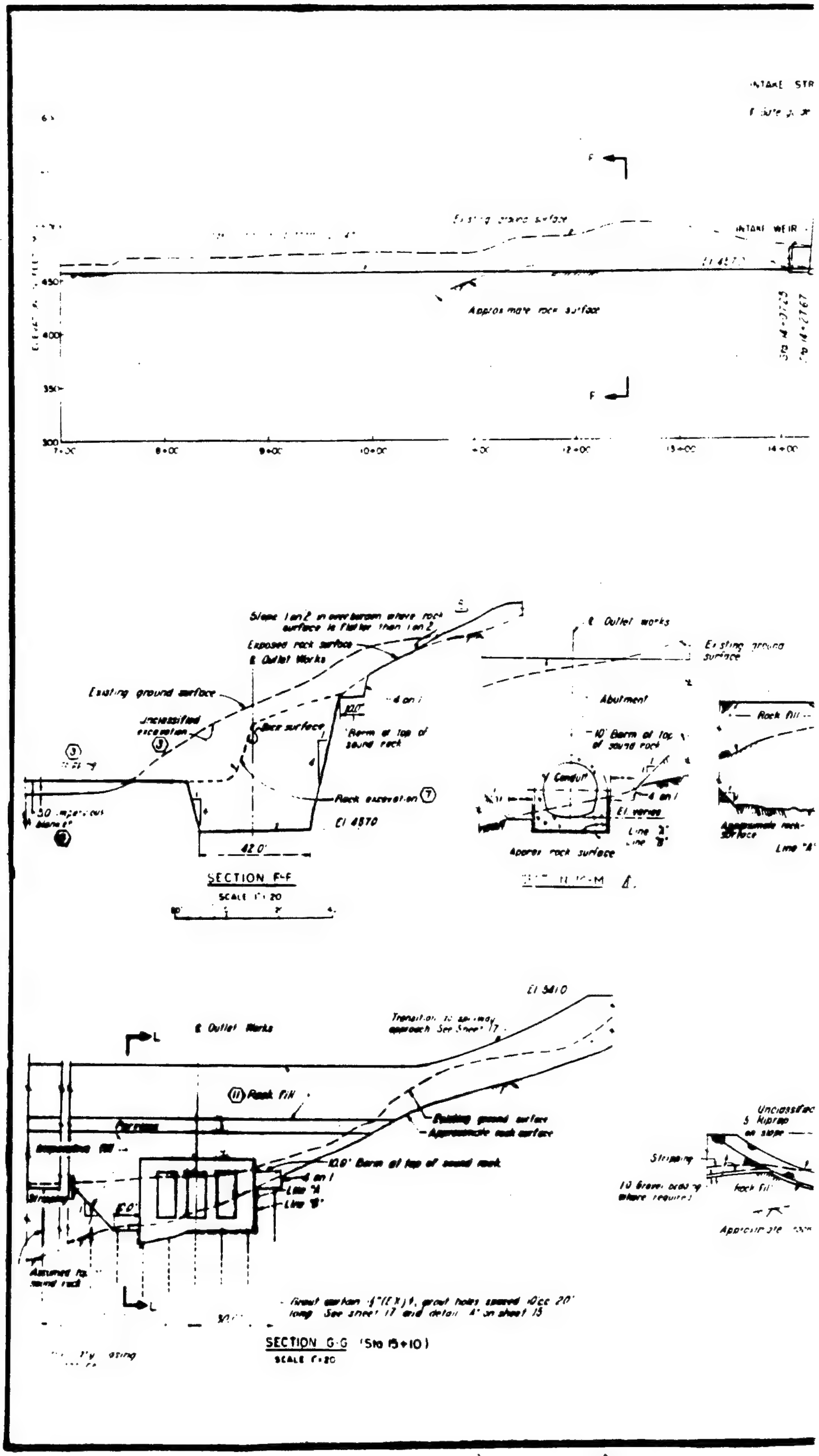
CONNECTICUT RIVER FLOOD CONTROL
BALL MOUNTAIN DAM
OUTLET WORKS AND SPILLWAY
PLAN AND SECTIONS
WEST RIVER VERMONT

DATE FEB 1957

SCALE AS SHOWN

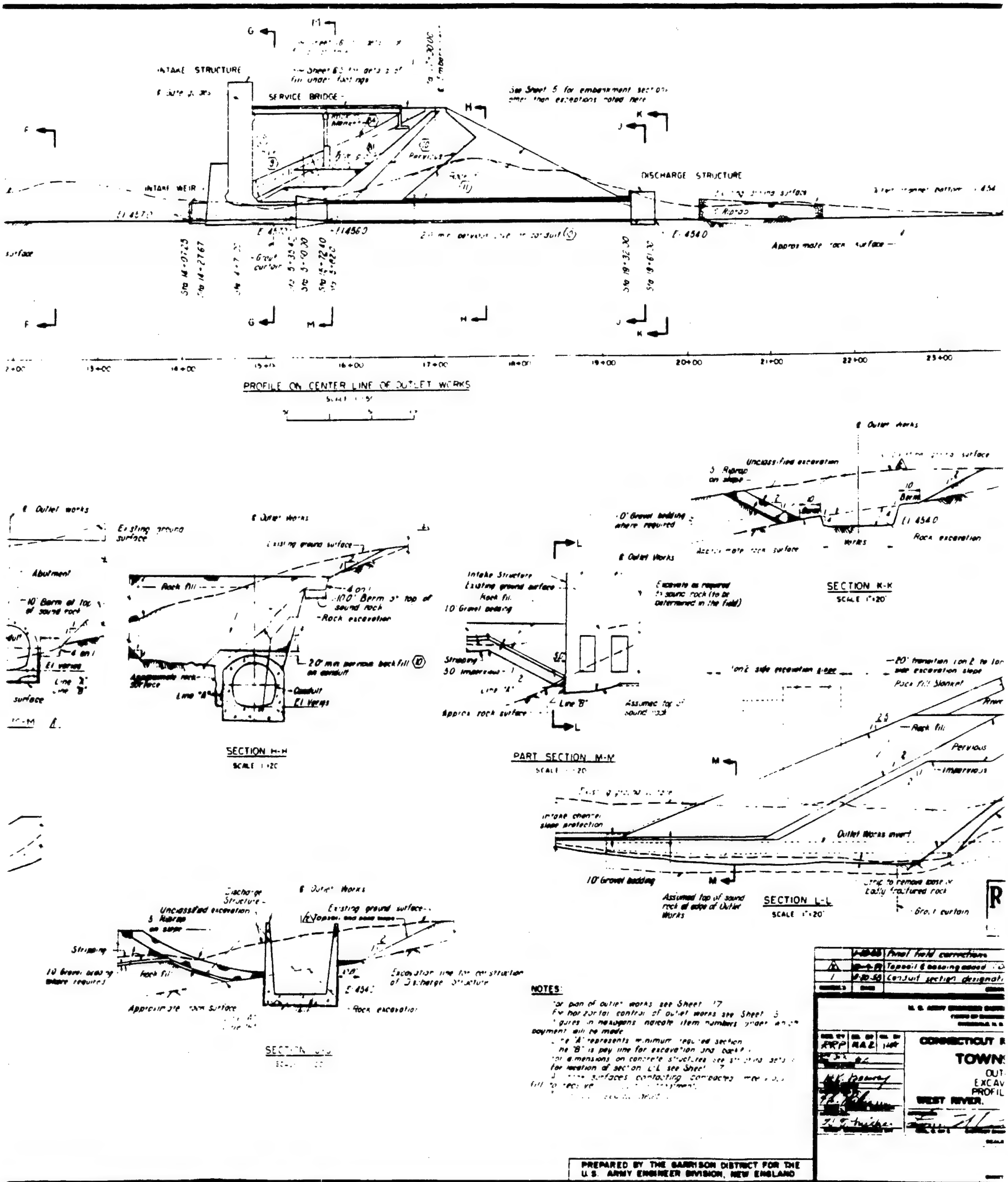
DRAWING NUMBER CT-1-4176

PLATE B-2



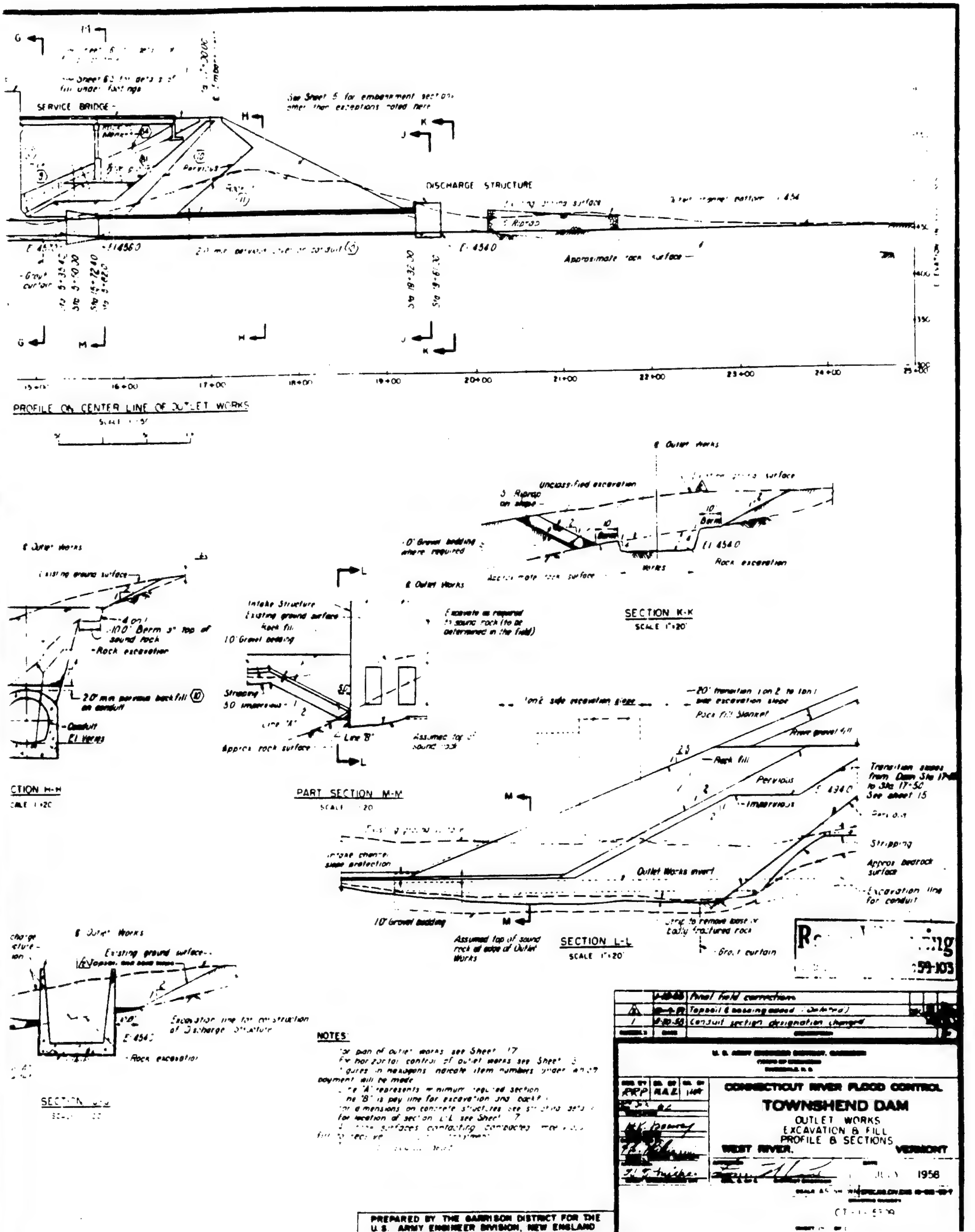
SECTION F-F
SCALE 1"=20

SECTION G-G (Sta 15+10)
SCALE 1"=20



NOTES:

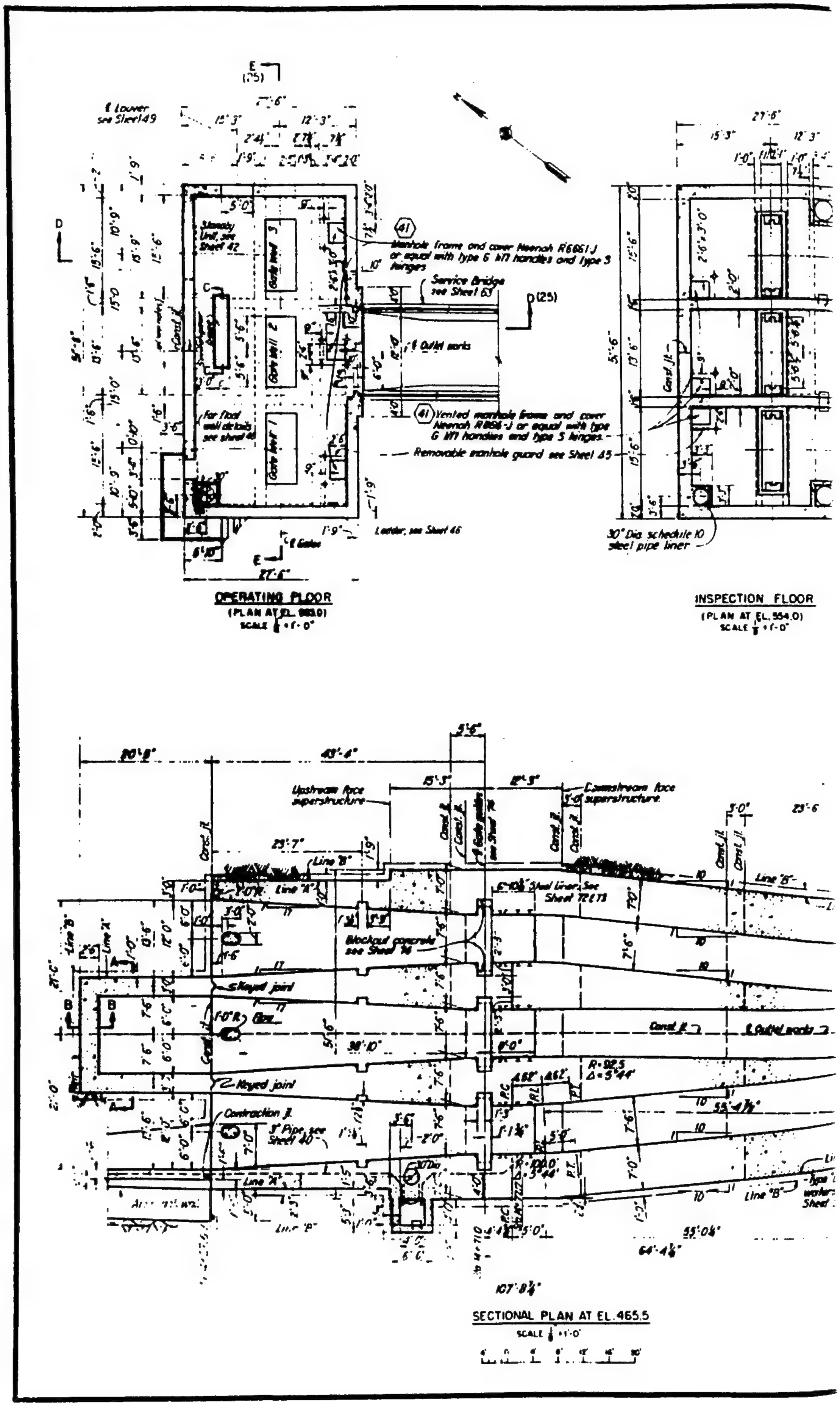
For plan of outlet works see Sheet 17.
For horizontal control of outlet works see Sheet 3.
Figures in hexagons indicate item numbers under which payment will be made.
Line "A" represents minimum required section.
Line "B" is pay line for excavation and backfill.
For dimensions on concrete structures see structural details.
For location of section L-L see Sheet 17.
[illegible] surfaces contacting compacted [illegible] fill to receive [illegible]



SERVICE BRIDGE
See Sheet 5 for embankment sections other than exceptions noted here
DISCHARGE STRUCTURE
Approximate rock surface
El 454.0
PROFILE ON CENTER LINE OF OUTLET WORKS
15+00
16+00
17+00
18+00
19+00
20+00
21+00
22+00
23+00
24+00
25+00
Unclassified excavation
Riprap on slope
Rock excavation
SECTION K-K
SCALE 1"=20'
Existing ground surface
10.0' Berm 3' top of sound rock
Rock excavation
2.0' min pervious backfill (10) on conduit
Conduit
El Varies
SECTION H-H
Intake Structure
Existing ground surface
Rock fill
1.0' Gravel bedding
Stripping
3.0 impervious
Line "A"
Line "B"
Approx. rock surface
Excavate as required to sound rock (to be determined in the field)
Assumed top of sound rock
PART SECTION M-M
Rock fill blanket
Rock fill
Pervious
Impervious
Outlet Works invert
Transition slopes from Dam Sta 17+50 to Sta 17+50 See sheet 15
Stripping
Approx. bedrock surface
Excavation line for conduit
1.0' Gravel bedding
Assumed top of sound rock at edge of Outlet Works
SECTION L-L
SCALE 1"=20'
Grout curtain
Existing ground surface
Excavation line for construction of Discharge Structure
El 454.0
Rock excavation
NOTES:
Final field corrections
Topsoil & seeding added
Conduit section designation changed
CONNECTICUT RIVER FLOOD CONTROL
TOWNSHEND DAM
OUTLET WORKS
EXCAVATION & FILL
PROFILE & SECTIONS
WEST RIVER, VERMONT
1956
PREPARED BY THE GARRISON DISTRICT FOR THE U.S. ARMY ENGINEER DIVISION, NEW ENGLAND

PLATE B-3

(3)



Manhole frame and cover Neenah R6661-J or equal with type 6 lift handles and type 5 hinges
Service Bridge see Sheet 63
Outlet works
Vented manhole frame and cover Neenah R8656-J or equal with type 6 lift handles and type 5 hinges.
Removable manhole guard see Sheet 45
Ladder, see Sheet 46
30" Dia schedule 10 steel pipe liner
OPERATING FLOOR
(PLAN AT EL. 583.0)
INSPECTION FLOOR
(PLAN AT EL. 554.0)
Upstream face superstructure
Downstream face superstructure
Blockout concrete see Sheet 74
Keyed joint
Contraction Jt.
Line "A"
Line "B"
SECTIONAL PLAN AT EL. 465.5

(1)

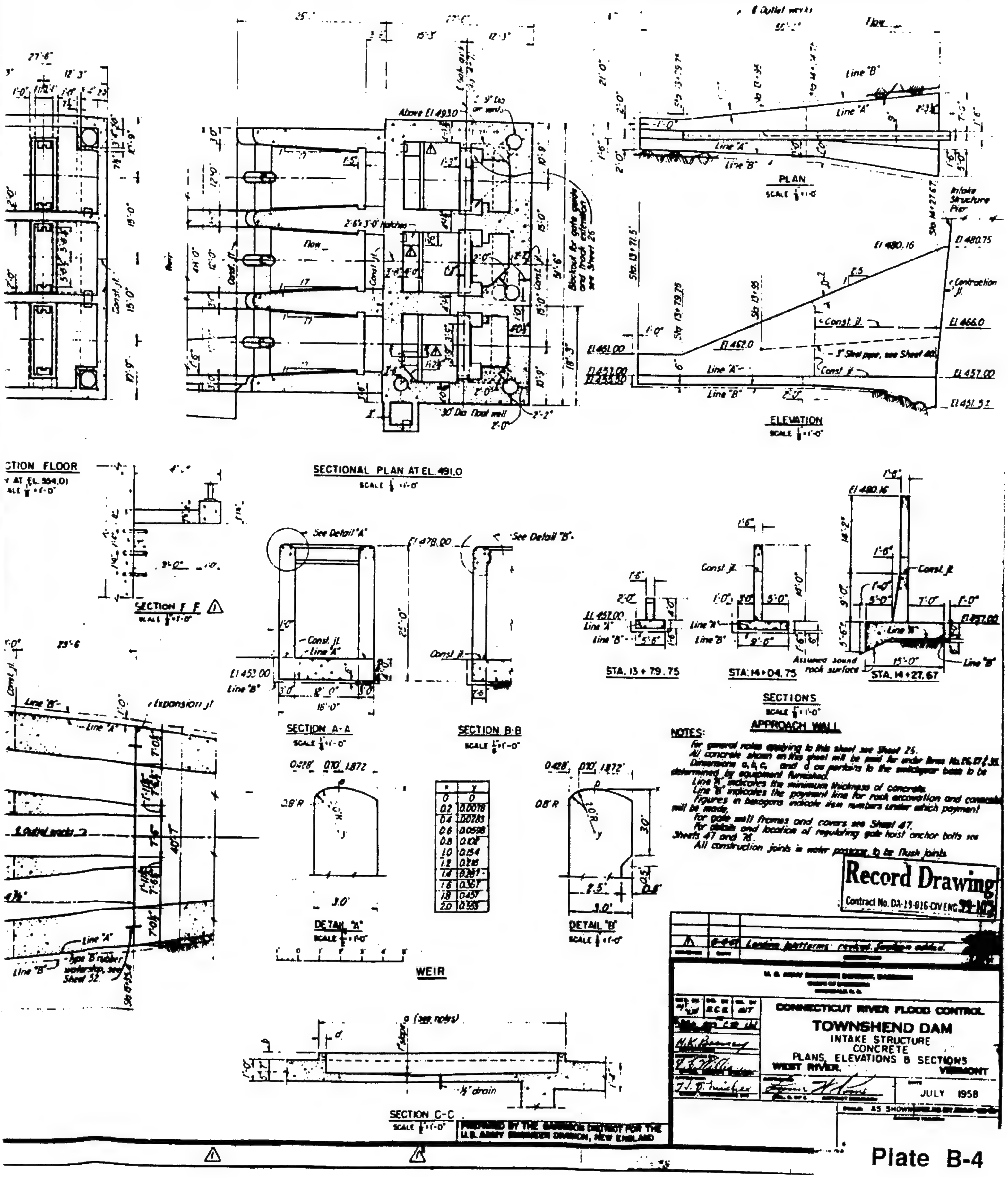
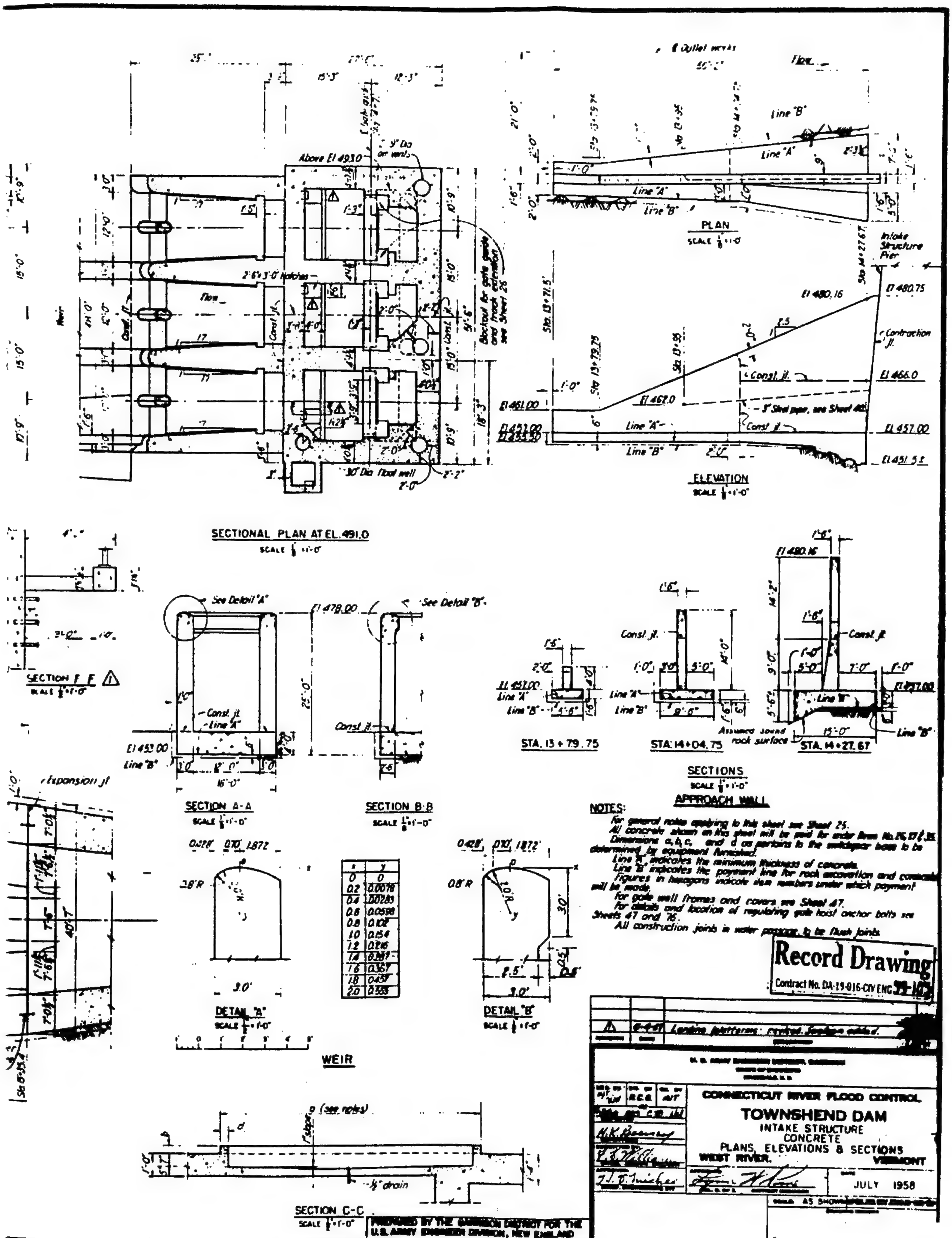

SECTIONAL PLAN AT EL. 491.0
PLAN
ELEVATION
SECTION F-F
SECTION A-A
SECTION B-B
STA. 13 + 79.75
STA. 14 + 04.75
STA. 14 + 27.67
SECTIONS
APPROACH WALL
DETAIL "A"
DETAIL "B"
WEIR
SECTION C-C
NOTES:
For general notes applying to this sheet see Sheet 25.
All concrete shown on this sheet will be paid for under Items No. 26, 27 & 35.
Dimensions a, b, c, and d as pertains to the switchgear base to be determined by equipment furnished.
Line "A" indicates the minimum thickness of concrete.
Line "B" indicates the payment line for rock excavation and concrete.
Figures in hexagons indicate item numbers under which payment will be made.
For gate well frames and covers see Sheet 47.
For details and location of regulating gate hoist anchor bolts see Sheets 47 and 76.
All construction joints in water passage to be flush joints.
Record Drawing
Contract No. DA-19-016-CIV ENG
CONNECTICUT RIVER FLOOD CONTROL
TOWNSHEND DAM
INTAKE STRUCTURE
CONCRETE
PLANS, ELEVATIONS & SECTIONS
WEST RIVER
VERMONT
JULY 1958
PREPARED BY THE GARRISON DISTRICT FOR THE U.S. ARMY ENGINEER DIVISION, NEW ENGLAND

Plate B-4

(2)



SECTIONAL PLAN AT EL. 491.0
SCALE 1/8" = 1'-0"
PLAN
SCALE 1/8" = 1'-0"
ELEVATION
SCALE 1/8" = 1'-0"
SECTION F-F
SECTION A-A
SECTION B-B
STA. 13+79.75
STA. 14+04.75
STA. 14+27.67
SECTIONS
APPROACH WALL
DETAIL "A"
DETAIL "B"
WEIR
SECTION C-C
NOTES:
For general notes applying to this sheet see Sheet 25.
All concrete shown on this sheet will be paid for under Items No. 26, 27 & 35.
Dimensions a, b, c, and d as pertains to the switchgear base to be determined by equipment furnished.
Line "A" indicates the minimum thickness of concrete.
Line "B" indicates the payment line for rock excavation and concrete will be made.
Figures in hexagons indicate item numbers under which payment will be made.
For gate well frames and covers see Sheet 47.
For details and location of regulating gate hoist anchor bolts see Sheets 47 and 76.
All construction joints in water passage to be flush joints.
Record Drawing
Contract No. DA-19-016-CIV ENG-59-103
Landing platforms revised, Sections added.
CONNECTICUT RIVER FLOOD CONTROL
TOWNSHEND DAM
INTAKE STRUCTURE
CONCRETE
PLANS, ELEVATIONS & SECTIONS
WEST RIVER, VERMONT
JULY 1958
PREPARED BY THE GARRISON DISTRICT FOR THE U.S. ARMY ENGINEER DIVISION, NEW ENGLAND

3

APPENDIX C

RADIO TELEMETRY STUDY OF OUT-MIGRATING ATLANTIC SALMON SMOLTS

A RADIO TELEMETRY STUDY
OF OUT-MIGRATING HATCHERY REARED ATLANTIC SALMON,
Salmo salar, SMOLTS RELEASED ABOVE TWO DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS' DAMS ON THE WEST RIVER, VERMONT

Prepared by

Larry Bandolin, Daniel M. Kuzmeskus, Albert U. Sillas
and Paul E. Clark
U.S. Fish & Wildlife Service
Sunderland Office Of Fisheries Assistance
51 East Plumtree Road
Sunderland, MA 01375

June 28, 1990

ABSTRACT

Thirty, hatchery reared Atlantic salmon (Salmo salar) smolts were externally tagged with radio transmitters and released on two dates above Ball Mountain and Townshend dams in the West River, Vermont. Their out-migration was monitored by continuously recording fixed telemetry systems with supplemental observations made using portable telemetry receivers. Twenty nine smolts were detected below the dam they were released above. All smolts passing through the dams they were initially released above did so within eleven hours, with twenty passing within three hours. Under the flow and operating conditions existing at the times of the releases, hatchery reared smolts encountered only slight delays.

A RADIO TELEMETRY STUDY OF OUT-MIGRATING HATCHERY REARED ATLANTIC SALMON, Salmo salar, SMOLTS RELEASED ABOVE TWO DEPARTMENT OF THE ARMY CORPS OF ENGINEERS' DAMS ON THE WEST RIVER, VERMONT

INTRODUCTION

A major effort is underway to restore Atlantic salmon to the Connecticut River. Knowledge of Atlantic salmon smolts (smolts) out-migrating from the Connecticut River Basin is important in assessing smolt production from the tributaries and their contribution to the restoration effort. The West River is a major tributary to the Connecticut River and is integral to the restoration of salmon to the Connecticut River basin. The West River, above Townshend Dam, contains approximately twenty thousand, 100 square yard units of juvenile salmon habitat. Between 40,000 and 80,000 smolts should be produced above Townshend Dam yearly. The fishery agencies, the Vermont Department of Fish and Wildlife (Vermont Fisheries) and the United States Fish and Wildlife Service (USFWS), have been stocking Atlantic salmon fry in the West River in order to utilize the juvenile salmon habitat to produce smolts. Studies by Vermont Fisheries have shown that survival and growth of juvenile salmon, stocked as fry, is very good in the West River.

Smolts produced above Ball Mountain Dam must pass through its

outlet and then pass through the Townshend Dam outlet on their way to the Connecticut River and finally to the ocean. These two dams are operated by Army, Corps of Engineers (Corps) for flood control. Fishery agencies were concerned about the potential delay to out-migrating smolts caused by the dams. This concern was greater for Ball Mountain Dam since the normal pool elevation during the time of smolt migration is maintained 65 feet above the outlet whereas at Townshend Dam the smolts could either exit through a surface outlet or through gates located about 21 feet below the outlet crest. Responding to these and other fish passage concerns, the Congress of the United States appropriated money, Public Law 101-101, to study the design and feasibility of providing fish passage at these two dams. As part of the planning process the Corps funded a study, conducted by the USFWS, to determine if either dam caused delays to migrating smolts. After discussions with the fishery agencies, the Corps agreed to maintain a pool level of 25 feet above the outlet at Ball Mountain Dam for the duration of the study. No changes in operations were made for Townshend Dam.

MATERIALS and METHODS

General

Radio telemetry was selected as the method to obtain data on smolts out-migrating through the two dams. Hatchery reared smolts were used as surrogates for stream reared smolts because of their availability. Smolt releases were made during the time of year that stream reared smolts would be expected to be migrating from the West River. The releases were made on May 16, 1990 and on May 23, 1990(Tables 1 and 2). Because of the configuration of the release structure at Ball Mountain, a deep outlet vs. surface and deep outlets at Townshend Dam, each release of smolts above Ball Mountain consisted of ten smolts, while each release above Townshend Dam consisted of five smolts. The study used both fixed and portable radio telemetry receivers. Fixed receivers were used to provide an automated continuous record of smolts passing through the two dams. Portable receivers were used to provide supplemental data on smolts above and below the two dams.

Radio Transmitters

Radio transmitters were selected for size and expected performance. Studies on the weight of the transmitters have demonstrated that they should not exceed 2 % of the fish's body weight (Ross and McCormick 1981; Mellas and Haynes 1985; and Marty and Summerfelt 1986). The method of transmitter attachment (external, surgical implant or stomach implant) may also impact fish movement and behavior. The external attachment method was selected because the smolts used were too small for stomach or surgical implants and because Mellas and Haynes (1985) found that externally tagged

rainbow trout (<u>Onchorynchus</u> <u>mykiss</u>) had significantly lower exhaustion times than other differently tagged groups in their study. Concern for exhaustion times arises from data that suggest that unexercised hatchery-reared Atlantic salmon have low stamina and are not strong enough to resist flow (Shustov and Shchurov 1988). Selection for external tag attachment is an effort to mitigate the affect of low stamina in hatchery-reared smolts. Specifications for the radio transmitters are presented in Appendix A.

Table 1. Passage data for radio tagged Atlantic salmon smolts out-migrating past the Corps of Engineers Ball Mountain flood control dam on the West River, Jamaica, Vermont.

Release Date & Time	Fish Number	First Detected In Impoundment (24 hours)	Time of Passage (24 hours)	Hours to Passage
5/16/90 1055	1	1229	1332	1.05
	2	1213	1427	2.23
	3	1211	Not Detected	----
	4	1145	2055	9.17
	5	1207	1252	0.75
	6	1302	1527	2.42
	7	Not Detected	1414	3.32 [1]
	8	1625	2124	4.98
	9	1152	1428	2.60
	10	Not Detected	1306	2.18 [1]
5/23/90 1045	1	1242	1713	4.52
	2	1219	1302	0.72
	3	1206	1334	1.47
	4	1145	1330	1.75
	5	1137	1227	0.83
	6	1136	1220	0.73
	7	1132	1206	0.57
	8	1149	1412	2.38
	9	1558	0224	10.43
	10	1558	0156	9.97

[1] Hours to passage calculated from time of release.

Table 2. Passage data for radio tagged Atlantic salmon smolts out-migrating past the Corps of Engineers Townshend flood control dam on the West River, Townshend, Vermont.

Release Date & Time	Fish Number	First Detected In Impoundment (24 hours)	Time of Passage (24 hours)	Hours to Passage
5/16/90	1	1134	1202	0.47
1000	2	1144	1222	0.63
	3	1145	1241	0.93
	4	1138	1147	0.15
	5	1155	2114	9.32
5/23/90	1	Not Detected	1831	8.60 [1]
955	2	1055	1110	0.25
	3	1105	1121	0.27
	4	1155	1212	0.28
	5	Not Detected	1744	7.82 [1]

[1] Hours to passage calculated from time of release.

Radio Receivers

The fixed receivers used were Smith-Root Model SR-40[R] 10-channel simultaneous search receivers connected to a Smith-Root Data Logger[R] (FDL-15P). The data logger is a data storage system allowing unattended continuous receiver operation. When a radio tagged smolt comes within range of the receiver a series of signals is sent to the data logger. The data logger measures the time interval between the signals received and the software program identifies the tag. Data collected and stored by the data logger are: tag identification code and the date and time of arrival and departure in 24 hour format. Data is retrieved from the data logger by direct connection to a computer. The portable receivers were the Advanced Telemetry System Model 2000[R] programmable receiver and AVM Instrument Co. Model LA 12[R]

[R] Use of trade names does not constitute endorsement of the product by the United States Fish and Wildlife Service.

Antenna

Two antenna types were used: tuned-loop directional antenna and 1/4 wavelength underwater antenna. Underwater antenna were made from RG 58 coaxial cable that were stripped of shielding for 1/4 wave length at the distal end allowing the center conductor to serve as the antenna. These antenna were connected to the fixed receivers and the tuned-loop antenna were connected to the portable receivers.

Receiver Locations

The two fixed receivers were located less than 100 yards down stream the outflow from the dam release structures. Portable receivers were used up on each release day, at the fixed receiver sites; these portable receivers were used as back ups for the fixed receivers. Observers with portable receivers were stationed upstream from each dam to determine when smolts reached the vicinity of the dam. These times gave a more accurate estimate of the amount of delay caused by the dam vs delay in migrating to the dam. If release time was used and smolts did not migrate to the dam the total time to passage would also include migration delays not associated with the dam. Two different upstream sites were used at Ball Mountain Dam. On the first release day the location was about 300 yards above the outlet tower; on the second release day the location was adjacent to the outlet tower at the waters edge. The change of location was made to get the receiver closer to the outlet, thus allowing more accurate estimate of when the smolts came into the vicinity of the dam. At Townshend Dam the portable receiver was positioned on the upstream side of the outlet control tower walkway for both releases.

Smolts

Atlantic salmon smolts were transported from the White River National Fish Hatchery, Bethel, VT, to the Richard C. Cronin National Salmon Station (RCNSS), Sunderland, MA, about three weeks before the study. The smolts were held in a 1.8 m^2 fiberglass tank with water flow rate of 0.76 Ls^{-1} and a water depth of 38 cm. They were fed daily and showed no abnormal behavior.

Smolts acceptable for tagging had to be greater than 180 mm; the smallest smolt tagged was 214mm. The tagging procedure was to anesthetize (MS-222), weigh, measure and then radio tag the smolts. The smolts were externally tagged by sewing on the transmitters using polypropylene thread and No. 5 darning needles. The first needle insertion was anterior to and slightly beneath the last dorsal fin ray. The second needle was inserted posterior to the location of the first needle at a distance equal to the tag length. The thread was tied securely using a surgeon's knot and the ends

clipped close to the knot. If bleeding occurred the tag was removed. Tag attachment required approximately 30 seconds. The smolts were placed back in the tank and held for about 24 hours after tagging before being released. None of the smolts showed unusual behavior after tagging.

Smolts were transported to the release site in two, 33 gallon plastic garbage cans containing about 25 gallons of water. No more than ten smolts were placed into each can. The trip to the release sites took about two hours. Previous work by the authors have shown that trips of this length and at these numbers of fish per can have caused no visible signs of stress to the fish. At the release site, the smolts were poured into the river at the shore.

Release sites were chosen for ease of access to the river and were far enough above the dam to provide the smolts an opportunity to acclimatize prior to coming close to the dam. The release site above Ball Mountain Dam is known as Pratts Bridge and is 1.6 miles above the dam. The release site above Townshend Dam was near the confluence of Tannery Brook and the West River and is 1.7 miles above the dam.

RESULTS and DISCUSSION

Ball Mountain Dam

On May 16, eight of the ten smolts released were detected in the vicinity of the dam(Table 1). It is possible that the two smolts not detected, had passed by the receiver location prior to the observer getting to the site and never entered the receiver's range. Nine out of the ten smolts released, including the two that were not detected above the dam, were detected below the dam.

On May 23, all ten smolts released were detected above the dam from the receiver located on the upstream dam face. This receiver location was better suited for determining when a smolt were in the vicinity of the dam. All smolts released were detected after passing through the dam.

Hours to passage were calculated from the first time the signal was received above the dam; or if the smolt was not detected above the dam, then the time from release was used. For the May 16 release, eight of the nine smolts passing through Ball Mountain Dam did so within five hours with six passing within three hours. On May 23, eight of ten smolts passed through within five hours. Eight smolts also passes Ball Mountain Dam on May 16 within five hours. However, six smolts passed within two hours on May 23, where only two passed within two hours on May 16. The flow on May 16 was between 600 and 630 cfs while on May 23 the flow was between 675 and 775 cfs. It is not known whether smolts passing through Ball

Mountain Dam were actively seeking a way through the dam or were involuntarily entrained. It is possible that the higher flows on May 23 either provided better attraction flows for the smolts that were actively seeking a way through or the higher flows entrained the smolts more quickly. Whatever the cause for passage the hatchery reared smolts released above Ball Mountain Dam encountered only slight delays under the flows and operating conditions present during this study.

Townshend Dam

On May 16, all five of the smolts released were detected in the vicinity of the dam and all passed through within 10 hours; with four passing within one hour(Table 2). The one smolt that was detected passing over nine hours after detection above the dam was believed to be swimming back and forth along the log boom and not near the outlet. On May 23, two of the five smolts released were not detected in the vicinity of the dam within five hours of release; but all five smolts did pass through Townshend Dam. The three smolts that were detected in the vicinity of the dam passed through the dam within 15 minutes of being detected. Discounting the two smolts which were not detected in the dam vicinity, passage at Townshend Dam showed the same pattern of passage as was seen at Ball Mountain Dam. Smolts at Townshend Dam passed through the dam more quickly when the river flows were higher. Smolts released at the Tannery Brook release site encountered only slight delays during this study.

The fishery agencies are concerned about the condition of the smolts that passed through the outlet at Ball Mountain Dam. This study did not attempt to answer this question. However, of the 19 smolts that passed through Ball Mountain Dam, 12 subsequently passed through Townshend Dam, three more were detected above Townshend Dam and the fate of the remaining four is unknown(Table 3). Twice as many smolts from the May 23 release passed through Townshend Dam than did smolts from the May 16 release; we cannot explain this difference. We feel that although the water levels immediately after each release were higher than average and it is possible, but unlikely, that injured or dead smolts could have been washed down river from Ball Mountain Dam ten miles to Townshend Dam and passed through Townshend Dam. Additional studies should be conducted to determine if injury or mortality are incurred by smolts passing through both dams.

Table 3. Passage data for radio tagged Atlantic salmon smolts outmigrating past two Corps of Engineers flood control dams on the West River, Vermont.

Release Date & Time	Fish Number	Passage Through Ball Mt. Dam Date	Time	Passage Through Townshend Dam Date	Time	Hours to Passage
5/16/90	2	5/16	1427	5/16	2222	7.92
1055	5	5/16	1252	5/16	2359	11.17
	7	5/16	1414	5/17	729	17.42
	10	5/16	1306	5/16	2120	8.23
5/23/90	2	5/23	1302	5/24	1122	22.33
1045	3	5/23	1334	5/25	155	36.35
	4	5/23	1330	5/26	2141	80.18
	5	5/23	1227	5/23	1703	4.50
	6	5/23	1220	5/23	2353	12.22
	7	5/23	1206	5/23	1746	5.67
	8	5/23	1412	5/23	2049	6.62
	9	5/24	224	5/24	1908	17.27

ACKNOWLEDGEMENTS

This project was supported with funds provided by Department of the Army, New England Division, Corps of Engineers. Order Number 90-C0025. Smolts were provided by the White River National Fish Hatchery, Bethel, VT. Smolt holding facilities were provided at the Richard C. Cronin National Salmon Station, Sunderland, MA. We gratefully acknowledge the cooperation of the staffs of Ball Mountain Dam and Townshend Dam, particularly Laurie Thorpe, Tim Flynn, Ralph Snow, and Larry McLaughlin. Mike Curran also provided direct assistance and made his staff, in addition to those mentioned above, available to us during the study. Mike Penko was instrumental in providing administrative and field support.

LITERATURE CITED

Marty, G.D. and B.C. Summerfelt. 1986. Pathways and mechanisms for expulsion of surgically implanted dummy transmitters from channel catfish. Transactions of the American Fisheries Society. 115(4):577-589.

Mellas, E.J. and J.M. Haynes. 1985. Swimming performance and behavior of rainbow trout (Salmo gairdneri) and white perch (Morone americana): effects of attaching telemetry transmitters. Canadian Journal of Fisheries and Aquatic Science. 42:488-493.

Ross, M.J. and J.H. McCormick. 1981. Effects of external radio transmitters on fish. Progressive Fish Culturist. 43(2):67-72.

Shustov, Yu. A. and I.L. Shchurov. 1988. Quantitative estimation of stamina of wild and hatchery-reared Atlantic salmon (Salmo salar L.). Aquaculture 71:81-87.

APPENDIX A

SPECIFICATIONS FOR RADIO TRANSMITTERS

1. Size - Finished Encapsulated Dimensions
   Maximum Length: 29 mm
   Maximum Diameter: 9 mm
   Max. In Water Weight: 2 g

2. Antenna: External or internal

3. Frequencies:
   Ten (10) at 10 KHz intervals that are tuned initially 1.0 KHz high and not dropping more than 2.0 KHz total over the operating life of the tag. The frequencies are: 30.17; 30.18; 30.19; 30.20; 30.21; 30.22; 30.23; 30.24; 30.25; and 30.26.

4. Transmitter Output:
   150 microwatts. This element is critical.

5. Pulse Width: 20 milliseconds: No variation

6. Pulse Rate:
   Three pulse rates: 60, 75, 95 and 115 pulses per minute (PPM) on each of the ten frequencies.

7. Pulse Interval: Constant: No variation.

8. Temperature Range:
   Transmitter must perform reliably to the above specifications within the 2-20 C.

9. Transmitting Life:
   Twenty-eight (28) days or longer with a silver oxide battery (SO-13?) or better in size and performance.

10. Magnetic Switch:
    Transmitter must be equipped and shipped with a magnetic reed switch that can be maintained in the off position with a small magnet taped to the exterior of the finished tag.

11. Tag Encapsulation:
    Encapsulating material must be non-toxic, preferably inert and should be soluble in a common solvent for the purpose of replacing the battery. The encapsulating material must be waterproof and durable. Bees wax is not acceptable.

12. External Attachment:
    The finished transmitter must have a one millimeter (1.0 mm) hole at each end of the radio tag (long axis) to accommodate a string for use in external attachment to the fish. The hole may either be drilled or embedded using microtubing.

APPENDIX D

DOWNSTREAM MIGRATION OF ATLANTIC SALMON SMOLTS, *Salmo salar*, PAST FLOOD CONTROL DAMS ON THE WEST RIVER IN VERMONT, 1991

DOWNSTREAM MIGRATION OF ATLANTIC SALMON SMOLTS, *Salmo salar*, PASSED FLOOD CONTROL DAMS ON THE WEST RIVER IN VERMONT, 1991

Prepared For The
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February 1992

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ABSTRACT

Paired releases of 15 hatchery and 15 wild Atlantic salmon, *Salmo salar*, smolts were made above each of two U.S. Army Corps of Engineers flood control projects in the West River, Vermont. Smolts were fitted with external radio transmitters and monitored as they migrated downriver through flood control impoundments and dams. Sacrificed radio tagged hatchery smolts released with live smolts at one location demonstrated that drift of dead smolts was minimal: the farthest distance any dead smolt drifted was 0.3 miles. Analyses included travel time (hours) in the free flowing reaches and passage time (hours) through the impoundments and dams. Two radio tagged smolts were either killed or lost their transmitters during passage through the upper flood control complex. Three additional transmitters from radio tagged smolts that passed through the upper flood control complex were recovered in the reach between the two flood control complexes. It is unknown if these smolts lost their transmitters, suffered serious injury during passage resulting in death, or died as a result of predation. Mean travel times for hatchery smolts through the free flowing segments was 1.5 to 3.5 times less than that observed for wild smolts. Mean passage time for wild smolts through the flood control complexes was approximately equal to or less than that for hatchery smolts. The potential for migration affected by the flood control complexes was examined by transforming travel time and passage time to migration rates (mph). The migration rate data indicate there was not a significant difference for either hatchery or wild smolts between travel to and passage through a single flood control complex. There was a finding of significance for hatchery smolts between travel to and passage through a second flood control complex: there was no difference for wild smolts. A diurnal migration rhythm for both hatchery and wild smolts was observed from the data records collected by the telemetry systems.

DOWNSTREAM MIGRATION OF ATLANTIC SALMON SMOLTS, Salmo salar, PASSED FLOOD CONTROL DAMS ON THE WEST RIVER IN VERMONT, 1991

INTRODUCTION

The West River is important to ongoing efforts to restore Atlantic salmon, *Salmo salar*, to the Connecticut River Basin. Although adult salmon have been documented returning to the West River, a spawning population does not yet exist. Working toward that important milestone, managers use the aquatic habitat of the drainage as rearing areas for juvenile hatchery salmon stocked as either fry or parr. Nearly 80 percent of the salmon rearing habitat in the West River basin is located above Townshend Lake and may annually produce an estimated 70,000 smolts. Approximately 43,000 of the estimated 70,000 smolts must pass both Ball Mountain Lake dam (River Mile 27.8) and Townshend Lake dam (River Mile 18.5) before reaching the mainstem of the Connecticut River during their annual migration to the sea (Figure 1).

Both of these projects are operated by the U.S. Army Corps of Engineers (COE) as flood control reservoirs. During the expected period of smolt downstream movement, the COE protocol (up to 1989) was to maintain the Ball Mountain Lake elevation 65 feet above the outlet and the Townshend Lake 21 feet above the outlet. Salmon smolts are generally associated with the upper few meters of the water column during outmigration and are not known for readily sounding to the depths required for passage from Ball Mountain Lake. In 1989 the Vermont Fish and Wildlife Department, Connecticut River Atlantic Salmon Commission, U.S. Fish and Wildlife Service (FWS), U.S. Forest Service, and COE agreed on the need to obtain more information on the fate of smolts encountering these two impoundments.

The COE received funding through Public Law 101-101 to study the feasibility and design of providing both upstream and downstream fish passage at these projects. As part of the planning process, the COE contracted with FWS for downstream fish passage studies at these impoundments in 1990 and 1991. Radio transmitter tags were used to determine the time and success of passage for hatchery-reared smolts (hatchery smolts) moving downstream through Ball Mountain and Townshend Lakes. Beginning in 1990 the COE protocol for pool elevation at Ball Mountain Lake was lowered from 65 feet

to 25 feet for the expected smolt outmigration period. No adjustment was made to the pool at Townshend Lake which was maintained at 21 feet above the outlet. Individual radio frequency signals from transmitters attached to smolts were tracked through both impoundments during 1990. Based on the results of that study, it was concluded that pool elevations of 25 feet at Ball Mountain Lake and 21 feet at Townshend Lake did not present a barrier to the downstream movement of smolts through the area under the high river flows that occurred during the study period. No attempt was made to recover smolts downstream of the lowermost dam. Two questions surfaced related to the 1990 study. What was the condition of smolts that passed through Ball Mountain Lake with the pool elevation protocol revised to 25 feet? Also, since only hatchery smolts were used, how closely did their behavior reflect that of stream-reared (wild) smolts from stocked hatchery fry? The 1991 study was an effort to gain more information on these valid questions. This report addresses the work accomplished in 1991.

MATERIALS AND METHODS

General

Atlantic salmon smolts each fitted with an external radio transmitter were released at different locations and times of day on May 9, 1991 (Figure 2). This date falls within the expected smolt outmigration period. The release of both hatchery and wild smolts above Ball Mountain Lake was followed by a similar release downstream between Ball Mountain Lake and Townshend Lake. The lowermost site was also used for the release of smolts sacrificed to monitor drift of smolts possibly killed after passing through Ball Mountain Lake dam. Comparative information was also gained by tracking signals from smolts released above Ball Mountain Lake dam that were received at the lowermost release site.

Both fixed and portable radio telemetry receivers were used in the study. Fixed receivers were used to provide an automated continuous record of smolts passing through each of the two dams. Portable receivers were used to provide supplemental data on signals transmitted outside the range of the fixed receiver locations.

Equipment

Radio transmitter tags were selected to match the expected size of study smolts and the required battery life. Studies by Ross and McCormick (1981); Mellas and Haynes (1985); and Marty and Summerfelt (1986) demonstrated that radio tags should not exceed 2 percent body weight of the study fish. Also, Shustov and Shchurov

(1988) provided data suggesting that unexercised hatchery Atlantic salmon have low stamina and are not strong enough to resist higher flows. Mellas and Haynes (1985) found that externally tagged rainbow trout, <u>Onchorynchus</u> <u>mykiss</u> had significantly longer exhaustion times than other differently tagged groups in their study. External radio tag placement was, therefore, selected based on this information and because available internal tags would be too large for the expected smolt size ranges.

Fixed radio receivers used were simultaneous search receivers interfaced to a data acquisition device. Data collected included the radio tag identification code, date, and times of arrival and departure relative to the search field. Portable receivers were also used to verify fish passage. A tuned-loop directional antenna was attached to each receiver.

A fixed receiver station was established downstream from the outflow of Ball Mountain Lake and Townshend Lake dams. At Ball Mountain Lake, the upstream receiver was located in the control tower near the impoundment face with the antenna pointed upstream toward the smolt release site. The upstream receiver at Townshend Lake was located one mile from the impoundment face.

Smolts

Smolts used in this study were from eggs incubated under controlled hatchery conditions. Some smolts, however, resulted from either fry or parr releases into the West River drainage where they developed into smolts under natural stream conditions. Most wild salmon in the West River smolt after two years, but without detailed scale analyses it can not be stated with certainty that one and three year old smolts were not included in the study. The wild smolts were captured in an inclined plane trap operated 3.5 miles upstream from Ball Mountain Lake prior to their release on May 9. The other study smolts were from salmon hatched from eggs in 1989 and reared to smolt condition after one year at the White River National Fish Hatchery, Bethel, Vermont. Both groups of smolts were transported to and held at the Richard Cronin National Salmon Station. The holding period ranged from seven to ten days for the wild smolts, and three weeks for the 1-year hatchery smolts. Extended holding time for hatchery smolts was determined by the availability of the smolts from the donor hatchery. Because of the longer holding period, hatchery smolts were offered feed at a rate similar to that applied by the donor hatchery. Wild smolts were not fed. Both groups were held under similar environmental conditions.

Tag Placement

Smolts were anesthetized before being fitted with a radio tag. The tag was attached with polypropylene thread using No. 5 darning needles. The first needle, inserted anterior to and slightly beneath the last dorsal fin ray, was followed by a second needle inserted posterior to that point by the approximate length of the radio tag. Improperly placed or secured tags were removed and those smolts eliminated from the study. No obvious behavioral change was noted after smolts were tagged and returned to the holding tank.

Smolt Releases

On May 8, the tagged smolts were transported to the release sites (Figure 2) in two aerated tanks of water (255 gallons each): a trip of approximately two hours. The Winhall River release site for Ball Mountain Lake (Release Site A) was 3.5 miles upstream from the dam). For Townshend Lake, the Cobb Brook release site (Release Site B) was 8.8 miles upstream from the dam and only 0.35 miles downstream from Ball Mountain Lake dam. At each release site smolts were held in screened floating cages (52 in. long x 24 in. wide and 18 in. deep) until released the following day. Smolts to be sacrificed were transported to the Cobb Brook release site on the day of release (May 9) in the aerated tanks described above. The smolts were sacrificed quickly by fracturing the vertebrae posterior to the head region.

Fifteen wild and 15 hatchery smolts were released at site "A" at 11:45 a.m. A similar release of 15 wild and 15 hatchery smolts occurred at site "B" at 12:45 p.m. Smolts were allowed to voluntarily exit the live cages at the appropriate release times. Dead smolts were released into the thalweg line of the river. Finally, 13 radio-tagged smolts were sacrificed and released at site "B" at 1300 Hours.

The study period was from May 9 - 16 for the Ball Mountain Lake study area and from May 9 - 29 for the Townshend Lake study area. Ball Mountain Lake pool elevation records from May 9 - 13 showed an average 25.2 feet and a range of 23.4 - 27.2 feet. Discharge records for the outfall from Ball Mountain Lake dam showed an average of 305.7 cfs and a range of 150 - 425 cfs. The flows decreased daily beginning with 425 cfs on May 9 and ending with 150 cfs on May 13. Discharge records from Ball Mountain Lake dam into the Townshend Lake study area were the same for the period May 9 - 13. Flows for the remainder of the Townshend Lake study (May 14-29) averaged 112.8 cfs and ranged from 52 - 225 cfs. Generally, flows decreased daily during the Townshend Lake study beginning with 425 cfs on May 9 and ending with 52 cfs on May 29. A large boulder located in the discharge plume from Ball Mountain Lake dam

presented a possible mechanism for mortality or injury to fish passing through the dam.

RESULTS

Observations from radio tagged fish passing fixed receiver locations provided sufficient data for comparative analyses at the Ball Mountain Lake and Townshend Lake study areas. The data recorded for analyses were used to compute travel time (hour) and migration rate (mph) variables for analyses. Specifically, the variables computed and analyzed were travel time and migration rate from a release site through a free-flowing reach, and passage time and migration rate from a specified location above the dam through the outfall.

Ball Mountain Lake Study Area

Thirteen hatchery and 14 wild smolts from the Winhall River release site were observed in Ball Mountain Lake at the telemetry receiver location. Observations at the outfall of Ball Mountain Lake dam revealed that 12 of the 13 hatchery smolts and 14 of the 14 wild smolts had passed through the dam.

Hatchery smolts reached Ball Mountain Lake in a mean time of 8.05 hours: wild smolts reached the same site in a mean time of 27.57 hours (Table 1). A comparison of hatchery to wild smolts travel times indicated a significant difference (t-test, $P = 0.015$); travel time for wild smolts averaged three times longer than travel time for hatchery smolts. All hatchery smolts reached the dam area on the release day; whereas, wild smolts took from one to 3.6 days.

Mean passage time through Ball Mountain Lake for hatchery vs. wild smolts was 2.20 and 2.09 hours, respectively (Table 1). A significant difference was not indicated for those passage times (t-test, $P = 0.091$). With the exception of one hatchery smolt that passed through the dam at 2:35 p.m., smolts moved through the dam between the hours of 9:20 p.m. and 6:54 a.m. with the majority (74 percent) passing between 9:20 p.m. and 1:40 a.m.

Migration rates were calculated both for smolts reaching the Ball Mountain Lake and smolts passing through the dam. The unit mph was used to standardize the data for comparison. The mean migration rates for hatchery smolts reaching Ball Mountain Lake and passing through the dam were 0.60 and 0.38 mph, respectively (Table 2). No significant difference (t-test, $P = 0.183$) in migration rate was indicated for hatchery smolts passage through the Dam (Table 3).

Mean migration rates for wild smolts reaching Ball Mountain Lake and passing through the dam were 0.24 and 0.56 mph, respectively (Table 2). No significant difference (t-test, $P = 0.063$) in

migration rate was found for wild smolts migrating to the dam vs. migrating through the dam (Table 3).

Townshend Lake Study Area

Data for this study area were obtained from the release of hatchery and wild smolts upstream at the Winhall River site and below Ball Mountain Lake at the Cobb Brook site. Winhall River and Cobb Brook released smolts were analyzed independently. The Cobb Brook release consisted of 15 live hatchery smolts, 13 dead hatchery smolts, and 15 wild smolts.

Data recorded on the "drift" of the dead smolts through the study area demonstrated that dead radio tagged smolts did not reach Townshend Lake. The farthest distance from the release site that a dead smolt drifted was 0.3 miles. Dead smolt observations were made until May 29 when the study was terminated.

Radio tag data recovered from the Cobb Brook smolt releases reaching Upper Townshend Lake (Receiver No. 3) revealed that 12 of the 15 hatchery smolts and 11 of the 15 wild smolts entered the lake. The same number of smolts passed through the lake and were recorded at the outfall of Townshend Lake dam (Receiver No. 4).

As previously described, of the 30 Winhall River released Atlantic salmon, 12 hatchery and 14 wild smolts passed through Ball Mountain Lake dam and were recorded at its outfall (Receiver No. 2). One hatchery and one wild smolt that passed through Ball Mountain Lake dam were either killed or separated from their radio transmitter. Stationary output from the transmitters were recorded from the time of passage until the receivers were removed on May 16. Observations at Receiver No. 3 of the Winhall River released smolts showed that nine hatchery and nine wild smolts entered Townshend Lake. Observations made with portable telemetry receivers located four (4) additional stationary smolts between Cobb Brook and Upper Townshend Lake. Three of the four fish located were wild smolts from the Winhall River release, the fourth was from a wild smolt released at Cobb Brook. Data recorded by Receiver No. 4 revealed that eight hatchery and seven wild smolts from the Cobb Brook release passed through Townshend Lake and Dam (Table 1). Seventy one percent of the smolt passage through Townshend Lake occurred between 10:22 p.m. and 5:34 a.m.

The mean travel time for the Winhall River released hatchery smolts from the outfall of Ball Mountain Lake dam to Receiver No. 3 was 5.35 hours (Table 1). Winhall River released wild smolts mean travel time between Receiver Nos. 2 and 3 was 15.55 hours. Passage time through the Townshend Lake dam impoundment and dam (from Receiver No. 3 to Receiver No. 4) for Winhall River released hatchery and wild smolts was 7.48 and 1.97 hours, respectively.

Cobb Brook released hatchery smolts mean travel time to Receiver No. 3 was 21.47 hours, whereas, Cobb Brook wild smolts traveled the distance in a mean time of 33.62 hours. Downstream from this free-flowing section, the Cobb Brook hatchery smolts passage time through the lake and dam was a mean of 4.96 hours, and wild smolt passage time was a mean of 6.51 hours (Table 1).

One-way ANOVA was used to test for the presence of significant differences in travel and passage times. Pairwise comparison probabilities for travel and passage times are presented (Table 4). The data demonstrate that travel time for Winhall River released hatchery smolts was significantly different than Cobb Brook releases of either hatchery smolts (f-test, $P = 0.026$) or wild smolts (f-test, $P < 0.001$). Winhall River released wild smolt travel time was significantly different (f-test, $P = 0.015$) than Cobb Brook wild smolts (Table 4). Passage time analysis (Table 4) for smolts travelling through Townshend Lake resulted in finding significant differences for Winhall River released wild smolts compared to Cobb Brook released hatchery (f-test, $P = 0.011$) and wild smolts (f-test, $P = 0.027$).

Travel and passage migration rates were calculated for each of the four groups of smolts in the Townshend Lake study area. The travel and passage rates were analyzed using t-tests. Mean travel and passage rates for Winhall River released hatchery smolts were 1.868 and 0.485 mph, respectively (Table 2). T-test analyses indicated there was a highly significant difference (t-test, $P < 0.001$) for this hatchery smolt group. Winhall River released wild smolt mean travel migration rate from the outfall of Ball Mountain Lake dam was 1.275 mph (Table 3). Their mean passage migration rate through Townshend Lake was 0.790 mph. No significant difference (t-test, $P = 0.216$) was calculated for the travel migration rate compared to the passage migration rate (Table 3).

Cobb Brook hatchery smolt mean travel and passage migration rates were 0.501 and 0.558, respectively (Table 3). A mean travel migration rate of 0.351 mph and a mean passage rate of 0.508 mph was calculated for Cobb Brook released wild smolts (Table 3). No significant difference in migration rates is apparent for Cobb Brook released hatchery or wild smolts.

DISCUSSION

With only a few exceptions noted below, smolts observed above either Ball Mountain Lake or Townshend Lake passed through the related dam. One smolt released at Winhall River failed to pass Ball Mountain Lake. Two smolts released at Winhall River reached Townshend Lake, but failed to pass. Signals from two radio-tagged smolts were found stationary at the outfall of Ball Mountain Lake dam after passage. It was assumed that either these smolts were

killed during passage or the tags were lost from the smolt at the outfall. Most radio-tagged smolt loses occurred in the free-flowing river study reach between the outfall of Ball Mountain Dam and Upper Townshend Lake. Losses from the Winhall release (6) were nearly equal to losses from the Cobb Brook release (7). Of the six smolts lost from the Winhall River release one (1) was a hatchery smolt and five (5) were wild smolts. Three of the five wild smolts were observed to be stationary in the river reach between Cobb Brook and Upper Townshend Lake. Two of the three transmitters were recovered from the stationary locations at the end of the study. Seven smolts from the Cobb Brook release (3 hatchery and 4 wild smolts) did not reach Upper Townshend Lake. A stationary Cobb Brook wild smolt was observed in the reach between Cobb Brook and Upper Townshend Lake. The transmitter was recovered at the observed location at the conclusion of the study. Possible explanations include tag failure or loss, loss of migratory behavior (desmoltification), or mortality from predation and other natural and man-induced causes and serious injury.

It was concluded that Winhall River released smolts detected downriver of Cobb Brook were alive and, therefore, included in the travel and passage data. Seventy five percent of the smolts that migrated through Ball Mountain Lake and 76 percent of the smolts released below Ball Mountain Lake (Cobb Brook) reached upper Townshend Lake. Travel rate data indicated that hatchery and wild smolt travel was approximately three and five times greater, respectively, for travel below Ball Mountain Lake dam than above Ball Mountain Lake dam. Additional evidence was provided by the drift of dead smolts: no smolt killed by passage through Ball Mountain Lake dam could have reached upper Townshend Lake. This conclusion was based on data from the release of the sacrificed smolts below Ball Mountain Lake dam. The downstream drift of these dead smolts was limited to no more than 0.3 miles.

Mean travel time for hatchery and wild smolts revealed that hatchery smolts traveled the monitored distances in fewer hours than did wild smolts. Mean travel time for hatchery smolts was approximately 1.5 to 3.5 times less than for wild smolts. The data indicate that radio-tagged hatchery smolts moved downstream from their respective release sites immediately and continually. Data suggest that wild smolts demonstrate a stop and go outmigration behavior. Observation time data reveal that outmigration for both hatchery and wild smolts occurred primarily during non-daylight hours.

Mean passage time for hatchery and wild smolts demonstrate that Winhall River released wild smolts passed through the impoundments and dams in nearly the same or less time than the hatchery smolts. This suggests that both hatchery and wild smolts demonstrate similar capabilities to pass through the impoundments and dams.

Migration rates (mph) were calculated to standardize the travel time (hours) on a per unit basis and provide a comparative data set. The migration rate data indicate there was not a significant difference for either hatchery or wild smolts between travel to and passage through Ball Mountain Lake dam. Migration rate comparison for the Townshend Lake study area indicated that hatchery smolts from the Winhall River release exhibited a statistically significant different rate for travel from the outfall of Ball Mountain Lake dam to upper Townshend Lake than passage through Townshend Lake impoundment and dam: wild smolts did not. Migration rates were not significantly different for hatchery and wild smolts released near Cobb Brook. It is possible the difference in travel and passage migration rates for hatchery smolts from the Winhall River release was related to their first passing through Ball Mountain Lake dam. A determination of whether this was a causal relationship or coincidence could be resolved by additional investigations.

The diurnal migration rhythm was noted in "snapshot" data records collected by the telemetry systems. Most (90 percent) of the 133 arrival and departure records for smolts occurred between the hours of 8:35 p.m. and 6:54 a.m. The data suggest that migration into Ball Mountain and Townshend Lakes and through the dams occurred primarily during non-daylight hours.

ACKNOWLEDGEMENTS

This project was supported with funds provided by the Department of the Army, New England Division, Corps of Engineers (Order Number 91-C-0021). Hatchery smolts were provided by the White River National Fish Hatchery, Bethel, Vermont. Smolt holding facilities were provided by the Richard Cronin National Salmon Station. The field portion of this study was supervised by Larry Bandolin who received special cooperation from the Ball Mountain Lake and Townshend Lake projects' staff: Laurie Thorpe, Tim Flynn, Ralph Snow, and Larry McLaughlin. Mike Penko was instrumental in providing administrative and field support. We thank Bob Stira and Dave Robinson of Northeast Utilities Service Company for loaning us the incline plane trap used for capturing the wild smolts. The assistance provided by Sunderland Office of Fishery Assistance staff Phil Herzig and Chris Davis and volunteer Michelle Babione were especially helpful.

LITERATURE CITED

Bandolin, L., D. M. Kuzmeskus, A. U. Sillas, and P. E. Clark. 1990. A radio telemetry study of out-migrating Atlantic salmon, *Salmo salar*, smolts released above two Department of the Army, Corps of Engineers' Dams on the West River, Vermont.

Marty, G. D. and B. C. Sumerfelt. 1986. Pathways and mechanisms for expulsion of surgically implanted dummy transmitters from channel catfish. Transactions of the American Fisheries Society. 115(4):577-589.

Mellas, E. J. and J. M. Haynes. 1985. Swimming performance and behavior of rainbow trout (*Salmo gairdneri*) and white perch(*Morone americana*): effects of attaching telemetry transmitters. Canadian Journal of Fisheries and Aquatic Science. 42:488-493.

Ross, M. J. and J. H. McCormick. 1981. Effects of external radio transmitters on fish. Progressive Fish Culturist. 43(2):67-72.

Shustov, Yu. A. and I. L. Shchurov. 1988. Quantitative estimation of stamina of wild and hatchery-reared Atlantic salmon (*Salmo salar* L.). Aquaculture 71:81-87.

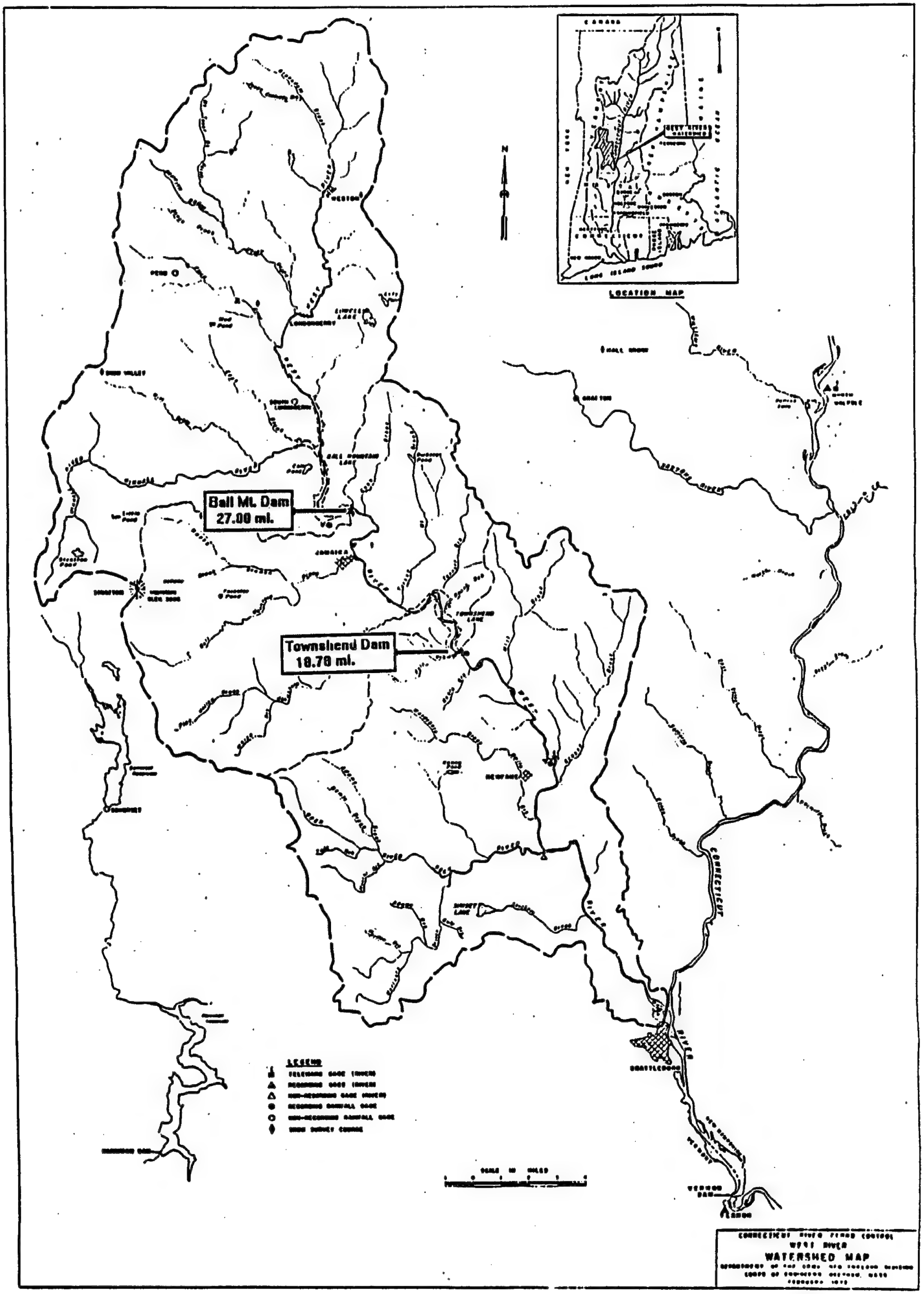

Figure 1. Location map for the West River watershed located in southeastern Vermont.

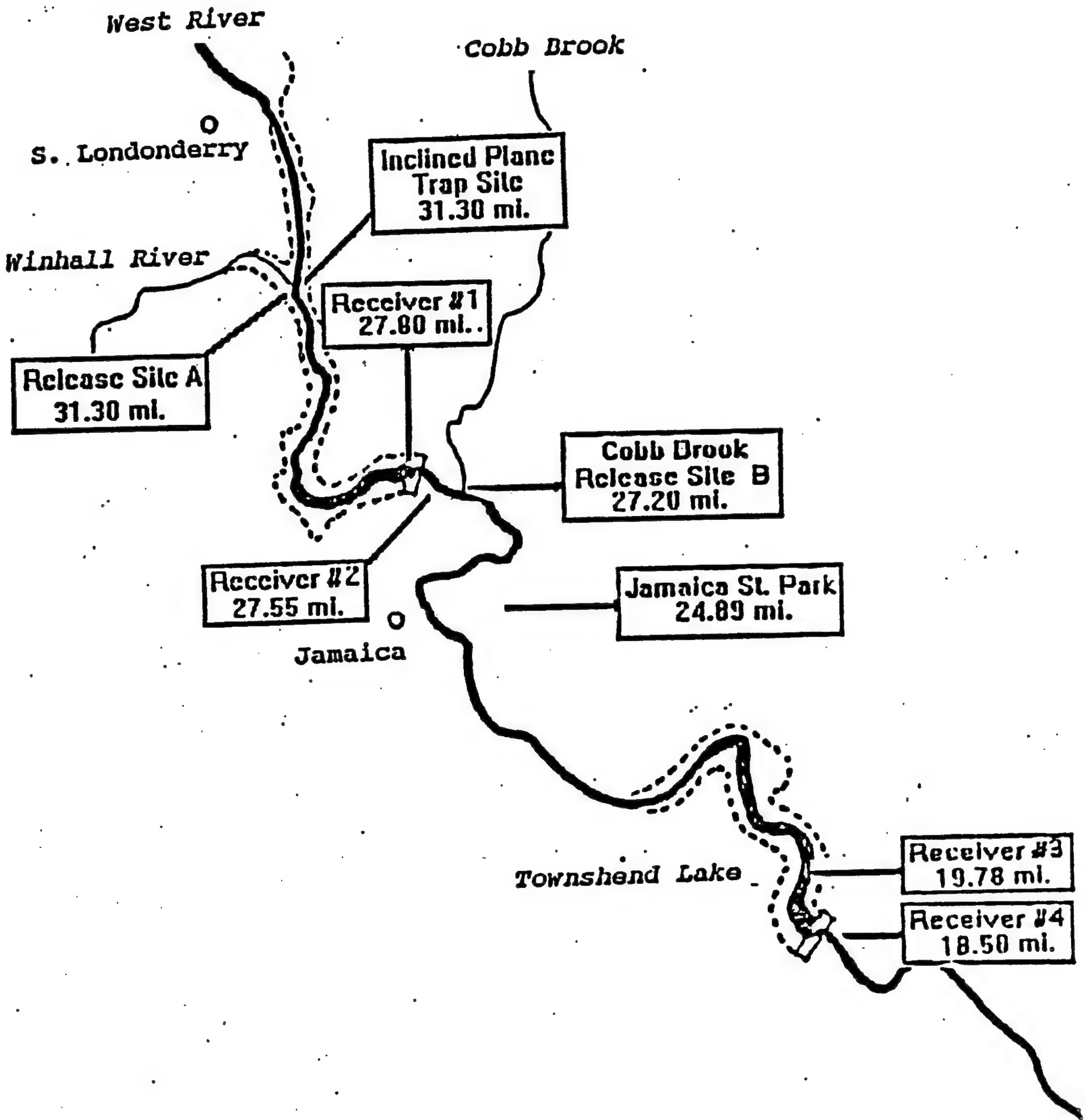

Figure 2. *Atlantic salmon release sites and telemetry monitoring locations for the 1991 West River, Vermont study.*

Table 1. *Downstream travel and passage statistics for radio-tagged Atlantic salmon smolts in the West River, Vermont, 1991.*

Release Location	Smolt Origin	Section Code[1]	Migration Time (hours) N	$\bar{X}$	SD	Range
Ball Mountain Lake Study Area						
Winhall River	Hatchery	Travel	13	8.05	3.19	1.97 - 10.90
Winhall River	Hatchery	Passage	12	2.20	3.37	0.32 - 12.30
Winhall River	Wild	Travel	14	27.57	25.86	9.27 - 86.24
Winhall River	Wild	Passage	14	2.09	2.80	0.15 - 9.09
Townshend Lake Study Area						
Winhall River	Hatchery	Travel	9	5.35	3.70	3.25 - 15.31
Winhall River	Hatchery	Passage	8	7.48	7.03	1.28 - 18.72
Winhall River	Wild	Travel	9	15.55	14.83	3.28 - 47.62
Winhall River	Wild	Passage	7	1.97	1.19	1.20 - 4.83
Cobb Brook	Hatchery	Travel	12	21.47	14.69	9.26 - 60.85
Cobb Brook	Hatchery	Passage	12	4.96	5.29	1.27 - 16.30
Cobb Brook	Wild	Travel	11	33.62	20.34	9.84 - 63.06
Cobb Brook	Wild	Passage	11	6.51	9.20	1.55 - 34.11

1/ Travel is code for free-flowing section
Passage is code for impounded section

Table 2. *Downstream travel and passage migration rates for radio-tagged Atlantic salmon smolts in the West River, Vermont, 1991.*

Release Location	Smolt Origin	Section Code[1]	Migration Rate (mph) N	$\bar{X}$	SD	Range
Ball Mountain Lake Study Area						
Winhall River	Hatchery	Travel	13	0.597	0.455	0.321 - 1.777
Winhall River	Hatchery	Passage	12	0.378	0.326	0.020 - 1.087
Winhall River	Wild	Travel	14	0.239	0.013	0.041 - 0.378
Winhall River	Wild	Passage	14	0.558	0.577	0.023 - 1.667
Townshend Lake Study Area						
Winhall River	Hatchery	Travel	9	1.868	0.722	0.508 - 2.746
Winhall River	Hatchery	Passage	8	0.485	0.460	0.068 - 1.320
Winhall River	Wild	Travel	9	1.275	0.901	0.163 - 2.369
Winhall River	Wild	Passage	7	0.790	0.245	0.265 - 0.955
Cobb Brook	Hatchery	Travel	12	0.501	0.229	0.122 - 0.801
Cobb Brook	Hatchery	Passage	12	0.558	0.351	0.176 - 1.008
Cobb Brook	Wild	Travel	11	0.351	0.230	0.125 - 0.754
Cobb Brook	Wild	Passage	11	0.508	0.323	0.133 - 0.826

1/ Travel is code for free-flowing section
Passage is code for impounded section

Table 3. *Comparison of mean migration rates of Atlantic salmon smolts in the West River, Vermont, 1991.*

Release Location	Smolt Origin	Mean Migration Rates (mph) By Section Code[1] Travel	Passage	Probability Value (P)
Ball Mountain Lake Study Area				
Winhall River	Hatchery	0.597	0.378	0.183
Winhall River	Wild	0.239	0.558	0.063
Townshend Lake Study Area				
Winhall River	Hatchery	1.868	0.485	<0.001
Winhall River	Wild	1.275	0.790	0.216
Cobb Brook	Hatchery	0.501	0.558	0.515
Cobb Brook	Wild	0.351	0.508	0.245

1/ Travel is code for free-flowing section
Passage is code for impounded section

Table 4. *One-way ANOVA matrix of paired probabilities for Atlantic salmon smolt migration times through both the adjacent upriver free-flowing reach (T) and the Townshend Lake impoundment (P) in the West River, Vermont, 1991.*

	Winhall River Releases Smolt Source		Cobb Brook Releases Smolt Source	
	Hatchery	Wild	Hatchery	Wild
Winhall River Releases				
Hatchery Smolts	(T) 1.000			
Hatchery Smolts	(P) 1.000			
Wild Smolts	(T) 0.179	(T) 1.000		
Wild Smolts	(P) 0.056	(P) 1.000		
Cobb Brook Releases				
Hatchery Smolts	(T) 0.026	(T) 0.401	(T) 1.000	
Hatchery Smolts	(P) 0.581	(P) 0.011	(P) 1.000	
Wild Smolts	(T) 0.001	(T) 0.015	(T) 0.074	(T) 1.000
Wild Smolts	(P) 0.834	(P) 0.027	(P) 0.711	(P) 1.000

APPENDIX A. Atlantic salmon data for the U.S. Army Corps of Engineers' West River, Vermont study for travel to Ball Mountain Lake and passage through Ball Mountain Dam.

No.	LOC.	ARRIVAL/ DEPART	DATE	TIME	WIN.R.TO BALL MT	U. BALL TO L BALL	ORIGIN	CH.
1	U.BALL MT.	A	05/09/91	13:43:19	1.97		H	10
1.5	U.BALL MT.	D	05/09/91	14:35:00	2.83	0.86	H	10
2	U.BALL MT.	A	05/09/91	14:36:02	2.85		H	13
2.5	U.BALL MT.	D	unk.	unk.	unk.	unk.	H	13
3	U.BALL MT.	A	05/09/91	15:31:55	3.78		H	12
3.5	U.BALL MT.	D	05/09/91	21:20:00	9.58	5.80	H	12
4	U.BALL MT.	A	05/09/91	16:39:50	4.91		H	6
4.5	U.BALL MT.	D	05/10/91	04:58:00	17.22	12.30	H	6
5	U.BALL MT.	A	05/09/91	21:01:26	9.27		W	7
5.5	U.BALL MT.	D	05/09/91	21:32:00	9.78	0.51	W	7
6	U.BALL MT.	A	05/09/91	21:02:18	9.29		W	12
6.5	U.BALL MT.	D	05/09/91	21:42:00	9.95	0.66	W	12
7	U.BALL MT.	A	05/09/91	21:03:00	9.30		W	6
7.5	U.BALL MT.	D	05/10/91	00:15:00	12.50	3.20	W	6
8	U.BALL MT.	A	05/09/91	21:13:00	9.47		H	14
8.5	U.BALL MT.	D	05/09/91	23:15:00	11.50	2.03	H	14
9	U.BALL MT.	A	05/09/91	21:26:19	9.69		H	11
9.5	U.BALL MT.	D	05/09/91	21:47:00	10.03	0.34	H	11
10	U.BALL MT.	A	05/09/91	21:34:35	9.83		H	8
10.5	U.BALL MT.	D	05/09/91	22:11:00	10.43	0.61	H	8
11	U.BALL MT.	A	05/09/91	21:36:08	9.85		H	1
11.5	U.BALL MT.	D	05/09/91	21:50:00	10.08	0.23	H	1
12	U.BALL MT.	A	05/09/91	21:47:31	10.04		H	9
12.5	U.BALL MT.	D	05/09/91	22:54:00	11.15	1.11	H	9
13	U.BALL MT.	A	05/09/91	22:02:10	10.29		H	2
13.5	U.BALL MT.	D	05/09/91	22:51:10	11.10	0.82	H	2
14	U.BALL MT.	A	05/09/91	22:13:13	10.47		H	3
14.5	U.BALL MT.	D	05/09/91	23:23:00	11.63	1.16	H	3
15	U.BALL MT.	A	05/09/91	22:16:44	10.53		W	14
15.5	U.BALL MT.	D	05/09/91	22:47:00	11.03	0.50	W	14
16	U.BALL MT.	A	05/09/91	22:20:29	10.59		H	4
16.5	U.BALL MT.	D	05/09/91	23:10:00	11.42	0.83	H	4
17	U.BALL MT.	A	05/09/91	22:33:15	10.80		W	8
17.5	U.BALL MT.	D	05/09/91	23:10:05	11.42	0.61	W	8
18	U.BALL MT.	A	05/09/91	22:39:17	10.90		H	15
18.5	U.BALL MT.	D	05/09/91	22:58:40	11.23	0.32	H	15
19	U.BALL MT.	A	05/09/91	22:48:44	11.06		W	1
19.5	U.BALL MT.	D	05/09/91	22:58:00	11.22	0.15	W	1
20	U.BALL MT.	A	05/09/91	23:13:14	11.47		W	3
20.5	U.BALL MT.	D	05/09/91	23:23:00	11.63	0.16	W	3
21	U.BALL MT.	A	05/09/91	23:13:26	11.47		W	5
21.5	U.BALL MT.	D	05/10/91	01:16:00	13.52	2.04	W	5
22	U.BALL MT.	A	05/10/91	00:12:03	12.45		W	11
22.5	U.BALL MT.	D	05/10/91	01:40:00	13.92	1.47	W	11
23	U.BALL MT.	A	05/10/91	21:43:39	33.98		W	4
23.5	U.BALL MT.	D	05/10/91	22:05:00	34.33	0.36	W	4

24	U.BALL MT.	A	05/10/91	22:50:26	35.09		W	9
24.5	U.BALL MT.	D	05/11/91	06:54:00	43.15	8.06	W	9
25	U.BALL MT.	A	05/12/91	03:03:03	63.30		W	13
25.5	U.BALL MT.	D	05/12/91	05:17:00	65.53	2.23	W	13
26	U.BALL MT.	A	05/12/91	11:29:45	71.75		W	2
26.5	U.BALL MT.	D	05/12/91	20:35:00	80.83	9.09	W	2
27	U.BALL MT.	A	05/13/91	01:59:39	86.24		W	10
27.5	U.BALL MT.	D	05/13/91	02:09:00	86.40	0.16	W	10
1	L.BALL MT.	A	05/09/91	21:20:53	9.60		H	12
1.5	L.BALL MT.	D	05/09/91	21:26:00	9.68	0.09	H	12
2	L.BALL MT.	A	05/09/91	21:32:51	9.80		W	7
2.5	L.BALL MT.	D	05/09/91	21:38:00	9.88	0.09	W	7
3	L.BALL MT.	A	05/09/91	21:42:51	9.96		W	12
3.5	L.BALL MT.	D	05/09/91	21:53:00	10.13	0.17	W	12
4	L.BALL MT.	A	05/09/91	21:47:31	10.04		H	11
4.5	L.BALL MT.	D	05/09/91	21:54:00	10.15	0.11	H	11
5	L.BALL MT.	A	05/09/91	21:50:00	10.08		H	1
5.5	L.BALL MT.	D	05/09/91	21:55:00	10.17	0.08	H	1
6	L.BALL MT.	A	05/09/91	22:11:59	10.45		H	8
6.5	L.BALL MT.	D	05/09/91	22:19:00	10.57	0.12	H	8
7	L.BALL MT.	A	05/09/91	22:33:25	10.81		H	3
7.5	L.BALL MT.	D	05/09/91	22:34:00	10.82	0.01	H	3
8	L.BALL MT.	A	05/09/91	22:47:42	11.05		W	14
8.5	L.BALL MT.	D	05/09/91	23:02:00	11.28	0.24	W	14
9	L.BALL MT.	A	05/09/91	22:51:01	11.10		H	2
9.5	L.BALL MT.	D	05/09/91	22:58:00	11.22	0.12	H	2
10	L.BALL MT.	A	05/09/91	22:54:16	11.15		H	9
10.5	L.BALL MT.	D	05/09/91	23:01:00	11.27	0.11	H	9
7	L.BALL MT.	A	05/09/91	22:58:40	11.23		H	15
11.5	L.BALL MT.	D	05/09/91	23:09:00	11.40	0.17	H	15
12	L.BALL MT.	A	05/09/91	22:58:44	11.23		W	1
12.5	L.BALL MT.	D	05/09/91	23:03:00	11.30	0.07	W	1
13	L.BALL MT.	A	05/09/91	23:10:05	11.42		W	8
13.5	L.BALL MT.	D	05/09/91	23:15:00	11.50	0.08	W	8
14	L.BALL MT.	A	05/09/91	23:10:48	11.43		H	4
14.5	L.BALL MT.	D	05/09/91	23:20:00	11.58	0.15	H	4
15	L.BALL MT.	A	05/09/91	23:15:19	11.51		H	14
15.5	L.BALL MT.	D	05/09/91	23:30:00	11.75	0.24	H	14
16	L.BALL MT.	A	05/09/91	23:23:46	11.65		W	3
16.5	L.BALL MT.	D	05/09/91	23:28:00	11.72	0.07	W	3
17	L.BALL MT.	A	05/10/91	00:15:41	12.51		W	6
17.5	L.BALL MT.	D	05/10/91	00:20:00	12.58	0.07	W	6
18	L.BALL MT.	A	05/10/91	01:16:31	13.53		W	5
18.5	L.BALL MT.	D	05/10/91	01:23:00	13.63	0.11	W	5
19	L.BALL MT.	A	05/10/91	04:58:18	17.22		H	6
19.5	L.BALL MT.	D	05/10/91	05:22:00	17.62	0.39	H	6
20	L.BALL MT.	A	05/10/91	04:58:24	17.22		H	9
20.5	L.BALL MT.	D	05/10/91	05:22:00	17.62	0.39	H	9
21	L.BALL MT.	A	05/09/91	14:35:01	2.83		H	10
21.5	L.BALL MT.	D	05/09/91	14:52:00	3.12	0.28	H	10

22	L.BALL MT.	A	05/10/91	17:43:32	29.98		D	7
22.5	L.BALL MT.	D	05/10/91	17:57:00	30.20	0.22	D	7
23	L.BALL MT.	A	05/10/91	17:43:35	29.98		D	12
23.5	L.BALL MT.	D	05/10/91	17:59:00	30.23	0.26	D	12
24	L.BALL MT.	A	05/10/91	22:05:24	34.34		W	4
24.5	L.BALL MT.	D	05/10/91	22:11:00	34.43	0.09	W	4
25	L.BALL MT.	A	05/11/91	01:40:32	37.93		W	11
25.5	L.BALL MT.	D	05/11/91	01:48:00	38.05	0.12	W	11
26	L.BALL MT.	A	05/11/91	06:54:46	43.16		W	9
26.5	L.BALL MT.	D	05/11/91	19:58:00	56.22	13.05	W	9
27	L.BALL MT.	A	05/12/91	05:17:10	65.54		W	13
27.5	L.BALL MT.	D	05/16/91	13:54:00	170.15	104.61	W	13
28	L.BALL MT.	A	05/12/91	20:35:12	80.84		W	2
28.5	L.BALL MT.	D	05/12/91	21:45:00	82.00	1.16	W	2
29	L.BALL MT.	A	05/13/91	02:09:54	86.42		W	10
29.5	L.BALL MT.	D	05/13/91	02:29:00	86.73	0.32	W	10

APPENDIX B. Atlantic salmon data for the U.S. Army Corps of Engineers West River, Vermont study for travel to Townshend Lake and passage through Townshend Lake Dam.

No.	LOC.	ARRIVAL/ DEPART	DATE	TIME	BALL MT/ COBB BK TO U.TND	HOLDING	ORIGIN	CH.
1	U.TND.DAM	A	05/09/91	21:22:07	6.50		H	10
1.5	U.TND.DAM	D	05/10/91	01:24:27	10.54	4.04	H	10
2	U.TND.DAM	A	05/09/91	22:00:35	9.26		H	8
2.5	U.TND.DAM	D	05/10/91	03:04:00	14.32	5.06	H	8
3	U.TND.DAM	A	05/09/91	22:35:38	9.84		W	1
3.5	U.TND.DAM	D	05/10/91	07:30:21	18.76	8.91	W	1
4	U.TND.DAM	A	05/09/91	22:59:32	10.24		H	15
4.5	U.TND.DAM	D	05/10/91	00:23:08	11.64	1.39	H	15
5	U.TND.DAM	A	05/09/91	23:01:54	10.28		H	6
5.5	U.TND.DAM	D	05/10/91	00:32:26	11.79	1.51	H	6
6	U.TND.DAM	A	05/10/91	00:04:44	11.33		W	2
6.5	U.TND.DAM	D	05/10/91	01:37:57	12.88	1.55	W	2
7	U.TND.DAM	A	05/10/91	00:32:21	11.79		H	14
7.5	U.TND.DAM	D	05/10/91	04:23:00	15.63	3.84	H	14
8	U.TND.DAM	A	05/10/91	01:04:15	12.32		H	2
8.5	U.TND.DAM	D	05/10/91	02:20:33	13.59	1.27	H	2
9	U.TND.DAM	A	05/10/91	01:21:00	3.92		H	12
9.5	U.TND.DAM	D	05/10/91	02:38:00	5.20	1.28	H	12
10	U.TND.DAM	A	05/10/91	01:39:46	3.78		W	12
10.5	U.TND.DAM	D	05/10/91	03:00:00	5.12	1.34	W	12
11	U.TND.DAM	A	05/10/91	01:57:40	3.64		H	8
11.5	U.TND.DAM	D	05/10/91	04:56:23	6.62	2.98	H	8
12	U.TND.DAM	A	05/10/91	02:16:00	3.25		H	9
12.5	U.TND.DAM	D	05/10/91	03:14:01	4.22	0.97	H	9
13	U.TND.DAM	A	05/10/91	02:19:54	2.83		H	14
13.5	U.TND.DAM	D	05/10/91	21:03:22	21.56	18.72	H	14
14	U.TND.DAM	A	05/10/91	01:56:17	2.97		H	2
14.5	U.TND.DAM	D	05/10/91	03:09:15	14.40	11.43	H	2
15	U.TND.DAM	A	05/10/91	02:24:27	13.66		W	12
15.5	U.TND.DAM	D	05/10/91	04:20:22	15.59	1.93	W	12
16	U.TND.DAM	A	05/10/91	02:26:52	13.70		W	10
16.5	U.TND.DAM	D	05/10/91	03:49:11	15.07	1.37	W	10
17	U.TND.DAM	A	05/10/91	02:36:00	3.57		W	14
17.5	U.TND.DAM	D	unk.	unk.	unk.	unk.	W	14
18	U.TND.DAM	A	05/10/91	02:44:35	3.28		W	3
18.5	U.TND.DAM	D	05/10/91	04:17:20	4.82	1.55	W	3
19	U.TND.DAM	A	05/10/91	02:59:32	14.24		H	11
19.5	U.TND.DAM	D	05/10/91	04:42:16	15.95	1.71	H	11
20	U.TND.DAM	A	05/10/91	03:17:42	5.38		H	1
20.5	U.TND.DAM	D	05/10/91	05:34:55	7.67	2.29	H	1
21	U.TND.DAM	A	05/10/91	03:39:01	4.32		H	4
21.5	U.TND.DAM	D	05/10/91	21:46:44	22.45	18.13	H	4
22	U.TND.DAM	A	05/10/91	04:03:30	15.31		H	15
22.5	U.TND.DAM	D	unk.	unk.	unk.	unk.	H	15

23	U.TND.DAM	A	05/10/91	04:19:15	15.57		H	1
23.5	U.TND.DAM	D	05/10/91	20:36:58	31.87	16.30	H	1
24	U.TND.DAM	A	05/10/91	03:17:50	4.25		W	1
24.5	U.TND.DAM	D	05/10/91	04:41:48	5.65	1.40	W	1
25	U.TND.DAM	A	05/10/91	05:11:26	16.44		W	13
25.5	U.TND.DAM	D	05/10/91	07:58:46	19.23	2.79	W	13
26	U.TND.DAM	A	05/10/91	05:28:32	16.73		H	4
26.5	U.TND.DAM	D	05/10/91	21:25:25	32.67	15.95	H	4
27	U.TND.DAM	A	05/10/91	18:37:48	29.88		H	10
27.5	U.TND.DAM	D	05/11/91	01:54:01	37.15	7.27	H	10
28	U.TND.DAM	A	05/10/91	20:54:01	32.15		H	13
28.5	U.TND.DAM	D	05/10/91	22:40:00	33.92	1.77	H	13
29	U.TND.DAM	A	05/10/91	21:06:02	20.77		W	6
29.5	U.TND.DAM	D	05/10/91	22:17:44	21.96	1.20	W	6
30	U.TND.DAM	A	05/10/91	23:07:35	34.38		H	12
30.5	U.TND.DAM	D	05/11/91	00:32:10	35.79	1.41	H	12
31	U.TND.DAM	A	05/11/91	00:59:56	25.75		W	8
31.5	U.TND.DAM	D	05/11/91	02:29:50	27.25	1.50	W	8
32	U.TND.DAM	A	05/11/91	01:13:16	36.47		W	15
32.5	U.TND.DAM	D	05/11/91	02:55:50	38.18	1.71	W	15
33	U.TND.DAM	A	05/11/91	02:13:57	4.05		W	4
33.5	U.TND.DAM	D	05/11/91	07:03:32	8.88	4.83	W	4
34	U.TND.DAM	A	05/11/91	03:24:29	38.66		W	11
34.5	U.TND.DAM	D	05/12/91	13:30:47	72.76	34.11	W	11
35	U.TND.DAM	A	05/11/91	04:17:52	26.91		W	5
35.5	U.TND.DAM	D	unk.	unk.	unk.	unk.	W	5
36	U.TND.DAM	A	05/11/91	14:27:03	49.70		W	6
36.5	U.TND.DAM	D	05/11/91	20:23:37	55.64	5.94	W	6
37	U.TND.DAM	A	05/11/91	21:15:03	47.62		W	7
37.5	U.TND.DAM	D	05/11/91	23:13:19	49.59	1.97	W	7
38	U.TND.DAM	A	05/11/91	22:20:00	57.58		W	9
38.5	U.TND.DAM	D	05/11/91	23:55:58	59.18	1.60	W	9
39	U.TND.DAM	A	05/12/91	00:08:04	59.38		W	7
39.5	U.TND.DAM	D	05/12/91	02:10:38	61.43	2.04	W	7
40	U.TND.DAM	A	05/12/91	01:35:43	60.85		H	3
40.5	U.TND.DAM	D	05/12/91	03:39:27	62.91	2.06	H	3
41	U.TND.DAM	A	05/12/91	03:48:21	63.06		W	3
41.5	U.TND.DAM	D	05/12/91	13:24:55	72.67	9.61	W	3

1	LTND.DAM	A	05/10/91	00:23:08	11.64		H	15
1.5	LTND.DAM	D	05/10/91	00:26:08	11.69	0.05	H	15
2	LTND.DAM	A	05/10/91	00:32:26	11.79		H	6
2.5	LTND.DAM	D	05/10/91	00:39:00	11.90	0.11	H	6
3	LTND.DAM	A	05/10/91	01:24:27	12.66		H	10
3.5	LTND.DAM	D	05/10/91	01:28:00	12.72	0.06	H	10
4	LTND.DAM	A	05/10/91	01:37:57	12.88		W	2
4.5	LTND.DAM	D	05/10/91	01:43:00	12.97	0.08	W	2
5	LTND.DAM	A	05/10/91	02:20:33	13.59		H	2
5.5	LTND.DAM	D	05/10/91	02:28:00	13.72	0.12	H	2
6	LTND.DAM	A	05/10/91	02:38:00	13.88		H	12
6.5	LTND.DAM	D	05/10/91	02:41:00	13.93	0.05	H	12
7	LTND.DAM	A	05/10/91	03:00:00	14.25		W	12
7.5	LTND.DAM	D	05/10/91	03:03:00	14.30	0.05	W	12
8	LTND.DAM	A	05/10/91	03:04:00	14.32		H	8
8.5	LTND.DAM	D	05/10/91	03:10:00	14.42	0.10	H	8
9	LTND.DAM	A	05/10/91	03:09:15	14.40		H	2
9.5	LTND.DAM	D	05/10/91	03:12:00	14.45	0.05	H	2
10	LTND.DAM	A	05/10/91	03:14:01	14.48		H	9
10.5	LTND.DAM	D	05/10/91	03:18:00	14.55	0.07	H	9
11	LTND.DAM	A	05/10/91	03:49:11	15.07		W	10
11.5	LTND.DAM	D	05/10/91	03:52:00	15.12	0.05	W	10
12	LTND.DAM	A	05/10/91	04:17:20	15.54		W	3
12.5	LTND.DAM	D	05/10/91	04:21:00	15.60	0.06	W	3
13	LTND.DAM	A	05/10/91	04:20:22	15.59		W	12
13.5	LTND.DAM	D	05/10/91	04:24:00	15.65	0.06	W	12
14	LTND.DAM	A	05/10/91	04:23:00	15.63		H	14
14.5	LTND.DAM	D	05/10/91	04:26:00	15.68	0.05	H	14
15	LTND.DAM	A	05/10/91	04:41:48	15.95		W	1
15.5	LTND.DAM	D	05/10/91	05:45:00	17.00	1.05	W	1
16	LTND.DAM	A	05/10/91	04:42:16	15.95		H	11
16.5	LTND.DAM	D	05/10/91	04:46:00	16.02	0.06	H	11
17	LTND.DAM	A	05/10/91	04:56:23	16.19		H	8
17.5	LTND.DAM	D	05/10/91	05:00:00	16.25	0.06	H	8
18	LTND.DAM	A	05/10/91	05:34:55	16.83		H	1
18.5	LTND.DAM	D	05/10/91	13:56:00	25.18	8.35	H	1
19	LTND.DAM	A	05/10/91	07:30:21	18.76		W	1
19.5	LTND.DAM	D	05/10/91	17:35:00	28.83	10.08	W	1
20	LTND.DAM	A	05/10/91	07:58:46	19.23		W	13
20.5	LTND.DAM	D	05/10/91	08:22:00	19.62	0.39	W	13
21	LTND.DAM	A	05/10/91	20:36:58	31.87		H	1
21.5	LTND.DAM	D	05/10/91	21:13:00	32.47	0.60	H	1
22	LTND.DAM	A	05/10/91	21:03:22	32.31		H	14
22.5	LTND.DAM	D	05/10/91	21:10:00	32.42	0.11	H	14
23	LTND.DAM	A	05/10/91	21:25:25	32.67		H	4
23.5	LTND.DAM	D	05/10/91	21:32:00	32.78	0.11	H	4
24	LTND.DAM	A	05/10/91	21:46:44	33.03		H	4
24.5	LTND.DAM	D	05/10/91	21:53:00	33.13	0.10	H	4
25	LTND.DAM	A	05/10/91	22:17:44	33.55		W	6
25.5	LTND.DAM	D	05/10/91	22:21:00	33.60	0.05	W	6

26	L.TND.DAM	A	05/10/91	22:40:00	33.92		H	13
26.5	L.TND.DAM	D	05/10/91	22:44:00	33.98	0.07	H	13
27	L.TND.DAM	A	05/11/91	00:32:10	35.79		H	12
27.5	L.TND.DAM	D	05/11/91	00:37:00	35.87	0.08	H	12
28	L.TND.DAM	A	05/11/91	01:54:01	37.15		H	10
28.5	L.TND.DAM	D	05/11/91	01:58:00	37.22	0.07	H	10
29	L.TND.DAM	A	05/11/91	02:29:50	37.75		W	8
29.5	L.TND.DAM	D	05/11/91	02:34:00	37.82	0.07	W	8
30	L.TND.DAM	A	05/11/91	02:55:50	38.18		W	15
30.5	L.TND.DAM	D	05/11/91	02:59:00	38.23	0.05	W	15
31	L.TND.DAM	A	05/11/91	07:03:32	42.31		W	4
31.5	L.TND.DAM	D	05/11/91	07:07:00	42.37	0.06	W	4
32	L.TND.DAM	A	05/11/91	20:23:37	55.64		W	6
32.5	L.TND.DAM	D	05/11/91	20:28:00	55.72	0.07	W	6
33	L.TND.DAM	A	05/11/91	23:13:19	58.47		W	7
33.5	L.TND.DAM	D	05/11/91	23:17:00	58.53	0.06	W	7
34	L.TND.DAM	A	05/11/91	23:55:58	59.18		W	9
34.5	L.TND.DAM	D	05/12/91	23:59:59	83.25	24.07	W	9
35	L.TND.DAM	A	05/12/91	02:10:38	61.43		W	7
35.5	L.TND.DAM	D	05/12/91	02:17:00	61.53	0.11	W	7
36	L.TND.DAM	A	05/12/91	03:39:27	62.91		H	3
36.5	L.TND.DAM	D	05/12/91	03:46:00	63.02	0.11	H	3
37	L.TND.DAM	A	05/12/91	13:24:55	72.67		W	3
37.5	L.TND.DAM	D	05/12/91	14:48:00	74.05	1.38	W	3
38	L.TND.DAM	A	05/12/91	13:30:47	72.76		W	11
38.5	L.TND.DAM	D	05/12/91	20:23:00	79.63	6.87	W	11

APPENDIX E

CONSTRUCTION COST ESTIMATES

		QUANTY UOM	CONTRACT	CONTINGN	ESCALATN	OTHER	TOTAL COST	UNIT
A FISH PASSAGE FACILITY								
A/06 FISH AND WILDLIFE FACILITIES								
A/06.1 FISH FACILITIES AT TOWNSEND DAM								
A/06.1.2 Collection, Holding & Transport								
A/06.1.2.B Site Work								
A/06.1.2.B/ 1	Clearing and Grubbling		6,879	344	236	0	7,459	
A/06.1.2.B/ 2	Excavation, Common	2600.00 CY	18,336	917	630	0	19,883	7.65
A/06.1.2.B/ 3	Gravel Bedding	320.00 CY	5,104	255	175	0	5,535	17.30
A/06.1.2.B/ 4	Compacted Gravel Fill	60.00 CY	1,184	59	41	0	1,284	21.40
A/06.1.2.B/ 5	Compacted Gravel Base Course	100.00 CY	1,973	99	68	0	2,140	21.40
A/06.1.2.B/ 6	Gravel Surface Course	900.00 CY	17,759	888	610	0	19,257	21.40
A/06.1.2.B/ 7	Compacted Random Fill	1700.00 CY	15,104	755	519	0	16,378	9.63
A/06.1.2.B/ 8	Stone Protection Class I	520.00 LF	16,661	833	573	0	18,066	34.74
A/06.1.2.B/ 9	Stone Protection Class II	275.00 LF	8,086	404	278	0	8,768	31.88
A/06.1.2.B/10	6" Topsoil and Seed	1900.00 SY	8,678	434	298	0	9,410	4.95
A/06.1.2.B/11	Guide Rail	270.00 LF	6,679	334	230	0	7,243	26.82
A/06.1.2.B/12	16' Single-Leaf Roadway Gate	2.00 EA	1,257	63	43	0	1,363	681.41
	Site Work		107,699	5,385	3,702	0	116,785	
A/06.1.2.C Concrete								
A/06.1.2.C/13	Fish Barrier	186.00 CY	56,871	2,844	1,955	0	61,669	331.56
A/06.1.2.C/14	East Retaining Wall	76.00 CY	33,337	1,667	1,146	0	36,150	475.65
A/06.1.2.C/15	West Retaining Wall	161.00 CY	62,930	3,146	2,163	0	68,240	423.85
A/06.1.2.C/16	Concrete Ramp 6"	17.00 CY	4,806	240	165	0	5,212	306.59
A/06.1.2.C/17	Concrete Slabs 8"	60.00 CY	11,690	585	402	0	12,677	211.28
A/06.1.2.C/18	Fish Collection Structure	72.00 CY	33,679	1,684	1,158	0	36,520	507.23
	Concrete	572.00 CY	203,313	10,166	6,988	0	220,467	385.43
A/06.1.2.E Metals								
A/06.1.2.E/19	Structural Steel Frame	3500.00 LB	10,390	519	357	0	11,266	3.22
A/06.1.2.E/20	Steel Racks for Barrier	12710 LB	53,386	2,669	1,835	0	57,890	4.55
A/06.1.2.E/21	Vertical Grating	1500.00 LB	3,045	152	105	0	3,302	2.20
A/06.1.2.E/22	Trash Racks	1200.00 LB	5,143	257	177	0	5,577	4.65
	Metals		71,963	3,598	2,474	0	78,035	

		QUANTY UOM	CONTRACT	CONTINGN	ESCALATN	OTHER	TOTAL COST	UNIT
1.2.P	Conveying Systems							
1.2.P/23	Brail Hoist		3,583	179	123	0	3,886	
1.2.P/24	Hoist System (Trolley Structure		6,429	321	221	0	6,972	
1.2.P/25	Hopper, Galvanized	600.00 LB	2,277	114	78	0	2,469	4.11
1.2.P/26	Brail Grating	1500.00 LB	2,643	132	91	0	2,866	1.91
	Conveying Systems		14,932	747	513	0	16,192	
1.2.R	Electrical							
1.2.R/23	Service Pole Work		406	20	14	0	440	
1.2.R/24	Underground Cable to Barrier	900.00 LF	18,561	928	638	0	20,127	22.36
1.2.R/25	Power to Hoists		9,143	457	314	0	9,915	
	Electrical		28,110	1,405	966	0	30,481	
	Collection, Holding & Transport		426,017	21,301	14,643	0	461,961	
1.8	Control and Diversion of Water							
1.8.B	Site Work							
1.8.B/25	Cofferdam Phase I	3150.00 SF	82,703	4,135	2,843	0	89,681	28.47
1.8.B/26	Cofferdam Phase II	4650.00 SF	63,231	3,162	2,173	0	68,565	14.75
	Site Work		145,934	7,297	5,016	0	158,246	
1.8.Q	Mechanical							
1.8.Q/26	Unwatering Cofferdam		5,481	274	188	0	5,943	
	Mechanical		5,481	274	188	0	5,943	
1.8.R	Electrical							
1.8.R/27	Power for Unwatering Pumps		993	50	34	0	1,076	
	Electrical		993	50	34	0	1,076	
	Control and Diversion of Water		152,407	7,620	5,238	0	165,266	
1.R	Associated General Items							

		QUANTY UOM	CONTRACT	CONTINGN	ESCALATN	OTHER	TOTAL COST	UNIT
A/06.1.R.C	Concrete							
A/06.1.R.C/31	Intake Weir Modifications		5,621	281	193	0	6,095	
	Concrete		5,621	281	193	0	6,095	
A/06.1.R.E	Metals							
A/06.1.R.E/32	Steel Sheetpiling Cutoff Wall	1320.00 SF	28,172	1,409	968	0	30,549	23.14
A/06.1.R.E/33	Chain Link Fence, 4' High	194.00 LF	2,751	138	95	0	2,983	15.38
	Metals		30,924	1,546	1,063	0	33,533	
A/06.1.R.L	Equipment: Transport Tank/Pump							
A/06.1.R.L/29	Tank for Pickup Truck		9,383	469	323	0	10,175	
A/06.1.R.L/30	Pump (to fill tank)		281	14	10	0	305	
	Equipment: Transport Tank/Pump		9,664	483	332	0	10,479	
	Associated General Items		46,209	2,310	1,588	0	50,107	
	FISH FACILITIES AT TOWNSEND DAM		624,633	31,232	21,470	0	677,334	
A/06.2	FISH FACILITIES AT BALL MTN DAM							
A/06.2.R	Associated General Items							
A/06.2.R.Q	Mechanical							
A/06.2.R.Q/33	Gate Automation		37,928	1,896	1,304	0	41,128	
	Mechanical		37,928	1,896	1,304	0	41,128	
	Associated General Items		37,928	1,896	1,304	0	41,128	
	FISH FACILITIES AT BALL MTN DAM		37,928	1,896	1,304	0	41,128	
	FISH AND WILDLIFE FACILITIES		662,561	33,128	22,773	0	718,462	
	FISH PASSAGE FACILITY		662,561	33,128	22,773	0	718,462	
	FISH PASSAGE FACILITY		662,561	33,128	22,773	0	718,462	

		QUANTY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT
A FISH PASSAGE FACILITY									
A/06 FISH AND WILDLIFE FACILITIES									
A/06.1 FISH FACILITIES AT TOWNSEND DAM									
A/06.1.2 Collection, Holding & Transport									
A/06.1.2.B Site Work									
A/06.1.2.B/ 1	Clearing and Grubbling		5,473	547	241	555	63	6,879	
A/06.1.2.B/ 2	Excavation, Common	2600.00 CY	14,590	1,459	642	1,479	167	18,336	7.05
A/06.1.2.B/ 3	Gravel Bedding	320.00 CY	4,061	406	179	412	46	5,104	15.95
A/06.1.2.B/ 4	Compacted Gravel Fill	60.00 CY	942	94	41	95	11	1,184	19.73
A/06.1.2.B/ 5	Compacted Gravel Base Cours	100.00 CY	1,570	157	69	159	18	1,973	19.73
A/06.1.2.B/ 6	Gravel Surface Course	900.00 CY	14,130	1,413	622	1,432	161	17,759	19.73
A/06.1.2.B/ 7	Compacted Random Fill	1700.00 CY	12,018	1,202	529	1,218	137	15,104	8.88
A/06.1.2.B/ 8	Stone Protection Class I	520.00 LF	13,257	1,326	583	1,344	151	16,661	32.04
A/06.1.2.B/ 9	Stone Protection Class II	275.00 LF	6,434	643	283	652	73	8,086	29.40
A/06.1.2.B/10	6" Topsoil and Seed	1900.00 SY	6,905	690	304	700	79	8,678	4.57
A/06.1.2.B/11	Guide Rail	270.00 LF	5,314	531	234	539	61	6,679	24.74
A/06.1.2.B/12	16' Single-Leaf Roadway Gat	2.00 EA	1,000	100	44	101	11	1,257	628.39
	Site Work		85,694	8,569	3,771	8,686	979	107,699	
A/06.1.2.C Concrete									
A/06.1.2.C/13	Fish Barrier	186.00 CY	49,578	4,958	2,181	5,025	566	56,871	305.76
A/06.1.2.C/14	East Retaining Wall	76.00 CY	29,062	2,906	1,279	2,946	332	33,337	438.64
A/06.1.2.C/15	West Retaining Wall	161.00 CY	54,860	5,486	2,414	5,561	627	62,930	390.87
A/06.1.2.C/16	Concrete Ramp 6"	17.00 CY	4,190	419	184	425	48	4,806	282.73
A/06.1.2.C/17	Concrete Slabs 8"	60.00 CY	10,191	1,019	448	1,033	116	11,690	194.84
A/06.1.2.C/18	Fish Collection Structure	72.00 CY	29,360	2,936	1,292	2,976	335	33,679	467.76
	Concrete	572.00 CY	177,241	17,724	7,799	17,965	2,024	203,313	355.44
A/06.1.2.E Metals									
A/06.1.2.E/19	Structural Steel Frame	3500.00 LB	9,057	906	399	918	103	10,390	2.97
A/06.1.2.E/20	Steel Racks for Barrier	12710 LB	46,540	4,654	2,048	4,717	532	53,386	4.20
A/06.1.2.E/21	Vertical Grating	1500.00 LB	2,655	265	117	269	30	3,045	2.03
A/06.1.2.E/22	Trash Racks	1200.00 LB	4,484	448	197	454	51	5,143	4.29
	Metals		62,735	6,274	2,760	6,359	717	71,963	

		QUANTY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT
A/06.1.2.P	Conveying Systems									
A/06.1.2.P/23	Brail Hoist			3,124	312	137	317	36	3,583	
A/06.1.2.P/24	Hoist System (Trolley Struc			5,605	560	247	568	64	6,429	
A/06.1.2.P/25	Hopper, Galvanized	600.00	LB	1,985	198	87	201	23	2,277	3.79
A/06.1.2.P/26	Brail Grating	1500.00	LB	2,304	230	101	234	26	2,643	1.76
	Conveying Systems			13,017	1,302	573	1,319	149	14,932	
A/06.1.2.R	Electrical									
A/06.1.2.R/23	Service Pole Work			354	35	16	36	4	406	
A/06.1.2.R/24	Underground Cable to Barrie	900.00	LF	16,181	1,618	712	1,640	185	18,561	20.62
A/06.1.2.R/25	Power to Hoists			7,971	797	351	808	91	9,143	
	Electrical			24,505	2,450	1,078	2,484	280	28,110	
	Collection, Holding & Trans			363,193	22,444	15,425	20,807	4,148	426,017	
A/06.1.B	Control and Diversion of Water									
A/06.1.B.B	Site Work									
A/06.1.B.B/25	Cofferdam Phase I	3150.00	SF	72,097	7,210	3,172	7,308	823	82,703	26.2
A/06.1.B.B/26	Cofferdam Phase II	4650.00	SF	55,122	5,512	2,425	5,587	630	63,231	13.6
	Site Work			127,220	12,722	5,598	12,895	1,453	145,934	
A/06.1.B.Q	Mechanical									
A/06.1.B.Q/26	Unwatering Cofferdam			4,778	478	210	484	55	5,481	
	Mechanical			4,778	478	210	484	55	5,481	
A/06.1.B.R	Electrical									
A/06.1.B.R/27	Power for Unwatering Pumps			865	87	38	88	10	993	
	Electrical			865	87	38	88	10	993	
	Control and Diversion of Wa			132,863	6,643	5,580	5,803	1,517	152,407	
A/06.1.R	Associated General Items									

		QUANTY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT
A/06.1.R.C	Concrete								
A/06.1.R.C/31	Intake Weir Modifications		4,900	490	216	497	56	5,621	
	Concrete		4,900	490	216	497	56	5,621	
A/06.1.R.E	Metals								
A/06.1.R.E/32	Steel Sheetpiling Cutoff Wa	1320.00 SF	24,560	2,456	1,081	2,489	280	28,172	21.34
A/06.1.R.E/33	Chain Link Fence, 4' High	194.00 LF	2,398	240	106	243	27	2,751	14.18
	Metals		26,958	1,348	1,132	1,178	308	30,924	
A/06.1.R.L	Equipment: Transport Tank/Pum								
A/06.1.R.L/29	Tank for Pickup Truck		8,180	818	360	829	93	9,383	
A/06.1.R.L/30	Pump (to fill tank)		245	25	11	25	3	281	
	Equipment: Transport Tank/		8,425	842	371	854	96	9,664	
	Associated General Items		40,283	2,014	1,692	1,760	460	46,209	
	FISH FACILITIES AT TOWNSEND		536,338	31,102	22,698	28,370	6,126	624,633	
A/06.2	FISH FACILITIES AT BALL MTN DAM								
A/06.2.R	Associated General Items								
A/06.2.R.Q	Mechanical								
A/06.2.R.Q/33	Gate Automation		33,064	3,306	1,455	3,351	378	37,928	
	Mechanical		33,064	3,306	1,455	3,351	378	37,928	
	Associated General Items		33,064	1,653	1,389	1,444	378	37,928	
	FISH FACILITIES AT BALL MTN		33,064	1,653	1,389	1,444	378	37,928	
	FISH AND WILDLIFE FACILITIE		569,403	32,755	24,086	29,814	6,503	662,561	
	FISH PASSAGE FACILITY		569,403	32,755	24,086	29,814	6,503	662,561	
	FISH PASSAGE FACILITY		569,403	32,755	24,086	29,814	6,503	662,561	
	Contingency							33,128	

	QUANTY UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT
SUBTOTAL							695,689	
Escalation							22,773	
TOTAL INCL OWNER COSTS							718,462	

TOWNSHEND LAKE - FISH COLLECTION FACILITY- PLAN A (CONCEPT ESTIMATE)

ITEM NO.	DESCRIPTION	EST. QTY	UNIT	UNIT PRICE	CONT.	EST. AMT.
1.00	FISH LOADING FACILITY					
1.01	Excavation	320	C.Y.	$10.00	20%	$3,840
1.02	Compacted Random Fill	810	C.Y.	$7.50	20%	$7,290
1.03	Stone Protection	260	C.Y.	$40.00	20%	$12,480
1.04	Stone Bedding	170	C.Y.	$30.00	20%	$6,120
1.05	Reinf. Concrete	100	C.Y.	$450.00	20%	$54,000
1.06	Hopper	1	JOB	$8,000.00	25%	$10,000
1.07	Brail	1	JOB	$8,000.00	25%	$10,000
1.08	Hoist System	1	JOB	$15,000.00	25%	$18,750
1.09	Road Gravel	90	C.Y	$20.00	20%	$2,160
1.10	Gravel Base Course	200	C.Y	$20.00	20%	$4,800
1.11	Bit.Conc.Binder Course 1 1/2"	610	S.Y.	$8.50	15%	$5,963
1.12	Tack Coat	610	S.Y.	$1.00	15%	$702
1.13	Bit.Conc.Surface Course -1 1/2"	610	S.Y.	$8.50	15%	$5,963
1.14	Topsoil & Seed	430	S.Y.	$6.00	20%	$3,096
1.15	Guide Rail	1	JOB	$2,600.00	20%	$3,120
1.16	Gate	1	JOB	$1,500.00	20%	$1,800
1.17	Paying Blocks	370	S.F.	$20.00	20%	$8,880
1.18	Grating	240	S.F.	$20.00	20%	$5,760
SUB TOTAL						$164,723

ITEM NO.	DESCRIPTION	EST. QTY	UNIT	UNIT PRICE	CONT.	EST. AMT.
2.00	DENIL TYPE FISHWAY WITH PUMPS					
2.01	Excavation	1500	C.Y.	$10.00	20%	$18,000
2.02	Compacted gravel Fill	950	C.Y.	$20.00	20%	$22,800
2.03	Reinf. Concrete	270	C.Y.	$400.00	20%	$129,600
2.04	Topsoil and Seed	150	S.Y.	$6.00	20%	$1,080
2.05	Grate and Rail	600	S.F.	$25.00	20%	$18,000
2.06	Inlet Grate	1	JOB	$10,000.00	20%	$12,000
2.07	Cofferdam	1	JOB	$20,000.00	20%	$24,000
2.08	Conduit	1	JOB	$15,000.00	20%	$18,000
2.09	Pumps	3	EA	$15,000.00	25%	$56,250
SUB TOTAL						$299,730
3.00	125' FISH BARRIER W/ CONTROLS					
3.01	Rack	125	LF	$650.00	20%	$97,500
3.02	Excavation	700	C.Y.	$15.00	20%	$12,600
3.03	Compacted Gravel Fill	50	C.Y.	$20.00	20%	$1,200
3.04	Paving Blocks	4900	S.F.	$15.00	20%	$88,200
3.05	Gravel Bedding	250	C.Y.	$20.00	20%	$6,000
3.06	Renif. Concrete	150	C.Y.	$250.00	20%	$45,000
3.07	Cofferdam	1	JOB	$12,500.00	20%	$15,000
3.08	Diversion of Water	1	JOB	$7,500.00	20%	$9,000
SUB TOTAL						$274,500

ITEM NO.	DESCRIPTION	EST. QTY	UNIT	UNIT PRICE	CONT.	EST. AMT.
4.00	GENERAL ITEMS					
4.01	Conduit	1	JOB	$8,000.00	20%	$9,600
4.02	Exterior LIghting	1	JOB	$5,000.00	20%	$6,000
4.03	Electric LIne W/ Poles	1	JOB	$5,000.00	20%	$6,000
4.04	Gated Tank on Truck	1	JOB	$8,000.00	25%	$10,000
SUB TOTAL						$31,600
TOTAL						$770,553
					USE	$770,000

TOWNSHEND LAKE - FISH COLLECTION FACILITY- PLAN B (CONCEPT ESTIMATE)

ITEM NO.	DESCRIPTION	EST. QTY.	UNIT	UNIT PRICE	CONT.	EST. AMT.
1.00	FISH LOADING FACILITY					
1.01	Excavation	270	C.Y.	$10.00	75%	$4,725
1.02	Compacted Random Fill	550	C.Y.	$7.50	20%	$4,950
1.03	Stone Protection	220	C.Y.	$40.00	20%	$10,560
1.04	Stone Bedding	120	C.Y.	$30.00	20%	$4,320
1.05	Reinf. Concrete	100	C.Y.	$450.00	20%	$54,000
1.06	Pumps	3	EA	$15,000.00	25%	$56,250
1.07	Hopper	1	JOB	$8,000.00	25%	$10,000
1.08	Brail	1	JOB	$8,000.00	25%	$10,000
1.09	Hoist System	1	JOB	$15,000.00	25%	$18,750
1.10	Road Gravel	60	C.Y	$20.00	20%	$1,440
1.11	Gravel Base Course	180	C.Y	$20.00	20%	$4,320
1.12	Bit.Conc.Binder Course 1 1/2"	550	S.Y.	$8.50	15%	$5,376
1.13	Tack Coat	550	S.Y.	$1.00	15%	$633
1.14	Bit.Conc.Surface Course -1 1/2"	550	S.Y.	$8.50	15%	$5,376
1.15	Topsoil & Seed	350	S.Y.	$6.00	20%	$2,520
1.16	Guide Rail	1	JOB	$3,200.00	20%	$3,840
1.17	Gate	1	JOB	$1,200.00	20%	$1,440
1.18	Grating	240	SF	$20.00	20%	$5,760
SUB TOTAL						$204,260

ITEM NO.	DESCRIPTION	EST. QTY.	UNIT	UNIT PRICE	CONT.	EST. AMT.
2.00	WEIR TYPE FISHWAY WITH WALKWAY					
2.01	Excavation	960	C.Y.	$10.00	20%	$11,520
2.02	Compacted gravel Fill	650	C.Y.	$20.00	20%	$15,600
2.03	Stone Bedding	160	C.Y.	$30.00	20%	$5,760
2.04	Stone Protection	320	C.Y.	$40.00	20%	$15,360
2.05	Gravel Base Course 6"	15	C.Y.	$20.00	20%	$360
2.06	Bit.Conc.Binder Course 1- 1/2"	75	S.Y.	$8.50	15%	$733
2.07	Tack Coat	75	S.Y.	$1.00	15%	$86
2.08	Bit.Conc.Surface Coarse 1-1/2"	75	S.Y.	$8.50	15%	$733
2.09	Reinf. Concrete	380	C.Y.	$400.00	20%	$182,400
2.10	Earth Support Sys. Permanent	3600	S.F.	$20.00	20%	$86,400
2.11	Earth Support Sys. Temp.	3300	S.F.	$10.00	20%	$39,600
2.12	Topsoil and Seed	150	S.Y.	$6.00	20%	$1,080
2.13	Stairway	1	JOB	$10,000.00	20%	$12,000
2.14	Inlet Structures	1	JOB	$10,000.00	20%	$12,000
2.15	Cofferdam	1	JOB	$20,000.00	75%	$35,000
2.16	Diversion of Water	1	JOB	$10,000.00	75%	$17,500
2.17	Grating	800	S.F.	$20.00	20%	$19,200
SUB TOTAL						$455,333

ITEM NO.	DESCRIPTION	EST. QTY.	UNIT	UNIT PRICE	CONT.	EST. AMT.
3.00	GENERAL ITEMS					
3.01	Conduit	1	JOB	$15,000.00	20%	$18,000
3.02	Exterior Lighting	1	JOB	$5,000.00	20%	$6,000
3.03	Electrical Line W/ Poles	1	JOB	$5,000.00	20%	$6,000
3.04	Rack (3'x 35') w/ C controls	1	JOB	$50,000.00	20%	$60,000
3.05	Gated Tank on Truck	1	JOB	$8,000.00	25%	$10,000
SUB TOTAL						$100,000
TOTAL						$759,593
					USE	$760,000

TOWNSHEND LAKE - FISH COLLECTION FACILITY- PLAN C (CONCEPT ESTIMATE)

ITEM NO.	DESCRIPTION	EST. QTY.	UNIT	UNIT PRICE	CONT	EST. AMT
1.00	FISH LOADING FACILITY					
1.01	Excavation - Rock	200	C.Y.	$80.00	25%	$20,000
1.02	Compacted Random Fill	30	C.Y.	$7.50	20%	$270
1.03	Stone Protection	20	C.Y.	$40.00	20%	$960
1.04	Stone Bedding	10	C.Y.	$30.00	25%	$375
1.05	Reinf. Concrete	100	C.Y.	$450.00	25%	$56,250
1.06	Pumps	3	EA	$15,000.00	25%	$56,250
1.07	Hopper	1	JOB	$8,000.00	25%	$10,000
1.08	Brail	1	JOB	$8,000.00	25%	$10,000
1.09	Hoist System	1	JOB	$40,000.00	25%	$50,000
1.10	Road Gravel	15	C.Y	$20.00	20%	$360
1.11	Gravel Base Course	140	C.Y	$20.00	20%	$3,360
1.12	Bit.Conc.Binder Course 1 1/2"	400	S.Y.	$8.50	15%	$3,910
1.13	Tack Coat	400	S.Y.	$1.00	15%	$460
1.14	Bit.Conc.Surface Course -1 1/2"	400	S.Y.	$8.50	15%	$3,910
1.15	Topsoil & Seed	140	S.Y.	$6.00	20%	$1,008
1.16	Guiderail	1	JOB	$2,400.00	20%	$2,880
1.17	Topsoil and Seed	1	JOB	$1,000.00	20%	$1,200
1.18	Haul Road	1	JOB	$25,000.00	25%	$31,250
1.19	Grate	1	JOB	$1,200.00	20%	$1,440
1.20	Grating	240	S.F.	$20.00	20%	$5,760
SUB TOTAL						$259,643

ITEM NO.	DESCRIPTION	EST. QTY.	UNIT	UNIT PRICE	CONT.	EST. AMT
2.00	WEIR TYPE FISHWAY WITH WALKWAY					
2.01	Excavation - Rock	340	C.Y.	$80.00	25%	$34,000
2.02	Compacted gravel Fill	490	C.Y.	$20.00	20%	$11,760
2.03	Gravel Base Course 6"	8	C.Y.	$20.00	20%	$192
2.04	Bit.Conc.Binder Course 1- 1/2"	50	S.Y.	$8.50	15%	$489
2.05	Tack Coat	50	S.Y.	$1.00	15%	$58
2.06	Bit.Conc.Surface Coarse 1-1/2"	50	S.Y.	$8.50	15%	$489
2.07	Reinf. Concrete	420	C.Y.	$400.00	25%	$210,000
2.08	Topsoil and Seed	100	S.Y.	$6.00	20%	$720
2.09	Stairway	1	JOB	$10,000.00	20%	$12,000
2.10	Inlet Structures	1	JOB	$10,000.00	20%	$12,000
2.11	Coffer Dam	1	JOB	$20,000.00	75%	$35,000
2.12	Diversion of Water	1	JOB	$10,000.00	75%	$17,500
2.13	Earth Support sys (permanent)	600	S.F.	$20.00	20%	$14,400
2.14	Grating	240	S.F.	$20.00	20%	$5,760
SUB TOTAL						$354,367
3.00	GENERAL ITEMS					
3.01	Conduit	1	JOB	$15,000.00	20%	$18,000
3.02	Exterior Lighting	1	JOB	$5,000.00	20%	$6,000
3.03	Electrical Line W/ Poles	1	JOB	$5,000.00	20%	$6,000
3.04	Rack (3'x 35') w/ controls	1	JOB	$50,000.00	20%	$60,000
3.05	Gated Tank	1	JOB	$8,000.00	25%	$10,000
SUB TOTAL						$100,000
TOTAL						$714,010
					USE	$710,000

APPENDIX F

RESERVOIR REGULATION EVALUATION

APPENDIX F

WEST RIVER FISH PASSAGE FACILITIES
BALL MOUNTAIN AND TOWNSHEND LAKES
RESERVOIR REGULATION EVALUATION

PREPARED BY
RESERVOIR CONTROL CENTER
WATER CONTROL DIVISION
ENGINEERING DIRECTORATE

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASSACHUSETTS

JANUARY 1992

APPENDIX F

WEST RIVER FISH PASSAGE FACILITIES
BALL MOUNTAIN AND TOWNSHEND LAKES
RESERVOIR REGULATION EVALUATION

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<u>BALL MOUNTAIN AND TOWNSHEND LAKES</u>
<u>RESERVOIR REGULATION EVALUATION</u>

1. DESCRIPTION OF WATERSHED

a. General. The West River watershed, as shown on plate F-1, is located in southern Vermont within the confines of Windham, Bennington, Rutland and Windsor Counties. It has a drainage area of 423 square miles of which 278 and 172 square miles lie upstream of Townshend and Ball Mountain Lakes, respectively. The watershed is generally elongated in shape, with a length of approximately 38 miles and a maximum width of 18 miles. Elevations vary from 220 feet NGVD at the mouth of the river to 3,500 feet NGVD at several points on the watershed divide.

The general topography of the watershed is hilly with steep wooded slopes from the mouth of the West River to Ball Mountain Lake. The watershed upstream from Ball Mountain Lake is mountainous with few natural or artificial ponds, therefore, the drainage area is conducive to rapid runoff.

The West River rises in the southeastern part of Mount Holly, Vermont. From its source to Ball Mountain Lake, the river flows in a southerly direction for about 23 miles and drops about 1,200 feet, it then flows in a southeasterly direction for about 9 miles to Townshend Lake with a drop of about 340 feet. From there the river continues in a southeasterly direction for approximately 19 miles and drops about 240 feet to its confluence with the Connecticut River at Brattleboro, Vermont.

The nondamaging channel capacity downstream of Ball Mountain Lake is about 5,000 cfs and 9,000 below Townshend Lake.

b. Tributaries. The principal tributaries of the West River are the Winhall River, Ball Mountain Brook, Wardsboro Brook and Rock River with respective drainage areas of about 60, 35, 36 and 59 square miles.

c. Physical Components

(1) Ball Mountain Lake. The important physical components of the project include a rolled earth and rockfill dam, chute spillway, outlet works, and storage for both flood control and recreation facilities. Pertinent data for the project is summarized on plate F-2.

(2) Townshend Lake. The important physical components of the project include a rolled earth and rockfill dam, side channel spillway, outlet works and storage for both flood control and recreation facilities. Pertinent data for the project is summarized on plate F-3.

d. Lake Storage

(1) Ball Mountain Lake. A small permanent pool is maintained to facilitate gate operations during the winter months. This 20-acre pool at elevation 830.5 feet NGVD has a water depth of 25 feet and about 240 acre-feet of storage. A conservation pool at elevation 870.5 feet NGVD is maintained during the summer. It has a depth of 65 feet, surface area of 75 acres and utilizes a net storage of 2,000 acre-feet. During the late fall, winter and spring months there is a net storage of 54,450 acre-feet set aside for flood control purposes. This volume is equivalent to 5.9 inches of runoff from the 172 square mile drainage area. During the recreation season, the net storage is reduced to 52,450 acre-feet, equivalent to 5.7 inches of runoff. The reservoir, when filled to spillway crest elevation 1017.0 feet NGVD, has a total capacity of 54,690 acre-feet, a surface area of 810 acres and a length of 6.5 miles. Area-capacity curves are shown on plate F-4.

(2) Townshend Lake. A permanent pool is maintained year-round to facilitate gate operations during the winter months and for recreational purposes during the summer. The pool has a depth of 21 feet, an area of 95 acres, utilizes a net storage of 800 acre-feet and is controlled by a 21-foot high concrete weir. The net storage of 32,900 acre-feet set aside for flood control purposes is equivalent to 5.8 inches of runoff from the 106-square mile drainage area below Ball Mountain Lake. The reservoir, when filled to spillway crest elevation 553.0 feet NGVD, has a total capacity of 33,700 acre-feet, a surface area of 735 acres and a length of 4.5 miles. Area- capacity curves are shown on plate F-5.

2. EXISTING RESERVOIR REGULATION PROCEDURES

The general objective of the regulation for the West River watershed is to provide the most efficient protection for communities immediately downstream on the West River and communities further downstream on the Connecticut River. This plan makes efficient use of water available for recreation on a seasonal basis without adversely affecting the flood storage capability of either project.

a. Regulation During Nonfreezing Season. During periods when lake levels are being raised or lowered, project personnel will be in contact with Reservoir Control Center (RCC) for instructions. During minor rises and periods of low flow, when gate changes are necessary to maintain a stable pool, project personnel will make the necessary changes without instructions from RCC.

(1) Ball Mountain Lake. During the month of May, following the spring snowmelt period, the pool will be raised to a stage of 65 feet for use as a conservation pool. The pool may be raised temporarily to a stage of about 70 feet for white water canoe races requested by the Appalachian Mountain Club (AMC). The amount of storage at a 70-foot stage is about 5 percent of total reservoir capacity. After the canoe races, discharges through Ball Mountain will be limited in order to stabilize the pool level.

The 65-foot conservation pool is maintained by throttling one gate with the other two gates closed. During a rising pool, the throttled gate may be opened to a maximum of 4 feet. However, if the pool rises above 75 feet, RCC will be notified. Following the recreation season, the 65-foot pool will be lowered to the 25-foot permanent pool. The maximum rate of reservoir drawdown should not exceed 20 feet in 24 hours; therefore, a minimum of two days is required to release about 2,000 acre-feet or a discharge of 500 cfs above the inflow rate for 48 hours. The drawdown may take place during September/October timeframe in order to assist AMC-sponsored canoe activities.

(2) Townshend Lake. A permanent recreation pool of about 21 feet, is maintained by the control weir located immediately upstream of the center gate. The two outside gates are closed and the center gate is set at a 5-foot opening. During minor rises, the two outside gates will be operated by the project manager, according to the following schedule, in order to minimize pool stage fluctuations.

GATE OPERATION SCHEDULE FOR
MAINTAINING RECREATION POOL

	Gate Settings (feet)		
Pool Stage (Rising)	#1	#2	#3
22	0	5	0
23	1	5	1
24	2	5	2
25 and rising		Notify RCC	

Pool Stage (Falling)

Leave gates at last setting until pool recedes to 22 feet, then lower both outside gates in 1-foot increments until pool stabilizes at 21 feet.

b. Regulation During Freezing Season. The Reservoir Control Center will instruct the operators when winter pools should be established in the fall and conservation pools in the spring.

(1) Ball Mountain Lake. The permanent pool is maintained at an approximate stage of 25 feet, with two gates closed and one gate throttled. During a rising pool, the throttled gate may be opened by project personnel to a maximum of 5 feet. If the pool rises above 50 feet, RCC should be notified.

(2) Townshend Lake. The weir is submerged by closing the center flood control gate and maintaining the 21-foot pool stage to keep all three flood control gates free from ice. The center gate and gate 3 are closed. The other outside gate will be partially open to maintain the winter pool. During a rising pool, the throttled gate may be opened to a maximum of 9 feet. If the pool continues to rise to a stage of 25 feet, RCC should be notified.

c. Regulation During Flood Period. Regulation of flows from Ball Mountain and Townshend Lakes are initiated for heavy rainfall occurring over the West River watershed and also for specific river stages at West and Connecticut River index stations. Regulation may be considered in three phases during the course of a flood. Phase I - the appraisal of storm and river conditions during the development of the flood leading to the initial regulation, phase II - regulation of the project while the West or Connecticut River floodflows crest and move downstream, phase III - emptying the reservoir following downstream recession of the flood.

(1) Phase I - Initial Regulation of Discharge. This phase is important as it is necessary to collect rainfall and discharge data in order to appraise the development and magnitude of a flood in the basin. Gate operations at Ball Mountain and Townshend Lakes will be initiated for the following conditions:

(a) Rainfall. Depending on antecedent conditions, past experience has indicated that 2 to 3 inches

of rainfall over the West River basin within 24 hours produces a moderate rise in river stages. Initial regulation of the reservoirs is necessary whenever the following rainfall has been recorded at either dam within a 24-hour period.

Rainfall/Inches (24-hour period)	Maximum Permissible Discharge Ball Mountain (cfs)	Townshend (cfs)
Less than 2	Maintain stable pool	Maintain stable pool
2 to 3	2,000	3,000
3 to 4	1,000	1,500
More than 4	25*	25*

* corresponds to minimum gate opening

(b) West River Stages. Ball Mountain and Townshend Lake outflows are restricted as necessary to maintain nondamaging channel capacities on the West River. High river stages are produced by runoff from rainfall, snowmelt or some other combination. Nondamaging channel capacities are as follows:

Location	Safe Channel Capacity (cfs)	Stage at (feet)	
Ball Mountain to Townshend	5,000	Jamaica	9.0
Townshend to Newfane	9,000	Newfane	9.6

(c) Connecticut River Stages. Ball Mountain and Townshend Lakes are also regulated in such a manner as to desynchronize West River flows with those on the main stem of the Connecticut River. For effective regulation, travel times of flows moving downstream the main stem must be taken into consideration. Regulation is initiated for the following rising Connecticut River stages.

Location	Stage (ft)	Maximum Reservoir Discharge Ball Mountain (cfs)	Townshend (cfs)
North Walpole			
Growing season	22	2,000	3,000
Nongrowing season	24	2,000	3,000
Montague City			
Growing season	20	2,000	3,000
Nongrowing season	23	2,000	3,000

(2) Phase II - Continuation of Regulation. An important activity during this period is the collection of hydrologic data such as: (a) precipitation totals throughout the watershed and surrounding areas, (b) snow cover and water content in case of spring floods, (c) stage and discharge values at downstream control points, and (d) other pertinent data which would assist in the regulation. During this phase, the reservoir discharge is regulated to reduce downstream flooding on the Connecticut River. Restriction of floodflows continues for the following rising river stages resulting primarily from rainfall:

Location	Stage (ft)	Maximum Reservoir Discharge Ball Mountain (cfs)	Townshend (cfs)
North Walpole			
Growing season	24	1,000	1,500
	26	25*	25*
Nongrowing season	26	1,000	1,500
	30	25*	25*
Montague City			
Growing season	23	1,000	1,500
	24	25*	25*
Nongrowing season	25	1,000	1,500
	26	25*	25*

* Outflow is restricted to 25 cfs for downstream aquatic life during phase II regulation

(3) Phase III - Emptying the Reservoirs. Following a high flow event, the reservoirs are emptied as rapidly as possible. Stored floodwaters are released in accordance with instructions issued by the RCC. In general, releases are based upon conditions on the Connecticut River and the amount of storage utilized in both reservoirs and other reservoirs in the system. The maximum rate of reservoir drawdown should not exceed 10 feet at Townshend and 20 feet at Ball Mountain in 24 hours. The rate of increase in reservoir discharge during the emptying period is not to exceed the following:

(a) Ball Mountain Lake - 1,000 cfs per hour until discharge reaches 4,000 and 500 cfs per hour between 4,000 to 5,000 cfs.

(b) Townshend Lake - 1,000 cfs per hour until discharge reaches 7,000 and 500 cfs per hour between 7,000 to 9,000 cfs.

NOTE: Outlet rating curves for Ball Mountain and Townshend Lakes are shown on plates F-6 and F-7.

(c) West River. Discharges from the projects will not exceed downstream channel capacities except under unusual conditions as directed by RCC. The rate of discharge to be released from Townshend Lake depends primarily on the stage at Newfane and is restricted to the channel capacity of 9,000 cfs. The rate of discharge from Ball Mountain Lake shall not exceed 5,000 cfs. In general, outflow from Ball Mountain will be regulated so available flood control storage is approximately the same at Townshend Lake.

(d) Connecticut River. Evacuation of stored floodwaters is not initiated until the flood crest has passed Montague City.

Phase III releases from Ball Mountain and Townshend Lakes are coordinated with releases from other projects in the Connecticut River Basin in a manner that allows Connecticut River flood crests to continue receding. Secondary river rises during phase III, due to either additional rainfall or snowmelt, may result in regulation procedures reverting to phase II.

3. PROPOSED CHANGES TO RESERVOIR REGULATION PROCEDURES

a. Flood Control. Installation of fish passage facilities at Ball Mountain and Townshend Lakes will not change flood control procedures at either project. Any

proposed structure for fish migration must be designed to accommodate maximum established channel capacities.

b. Normal Operating Procedures

(1) Townshend Lake. Installation of a proposed fish passage facility at Townshend Lake will not change normal operating procedures once construction is complete.

(2) Ball Mountain Lake. During the downstream fish migration months (April thru June) a 25-foot pool maintained. The normal 65-foot pool in May and June is considered to be fatal to fish "sounding" to the outlet works in order to swim downstream. This change in pool stage from 65 to 25 feet would require modifications to existing operating procedures at Ball Mountain Lake. Due to the flashy nature of the watershed and the narrow geometry of the reservoir valley, the Ball Mountain pool tends to rise and fall very quickly following a runoff event. As a result, manual operation of the flood control gates, in an effort to maintain the proposed 25 foot pool, is considered both difficult and extremely laborious. It is therefore recommended that an automated gate, to regulate outflow and maintain the desired pool level, be considered. It should be noted, however, that during low flow periods or drought years, it may be difficult to raise the pool to 65 feet for the ensuing summer season.

4. RESERVOIR REGULATION DURING FISH PASSAGE CONSTRUCTION

a. General. After investigation by the Geotechnical Engineering Division (GED), it is apparent that cofferdam heights must be limited due to subsurface site conditions. The reservoir regulation plan during fish passage construction was developed to satisfy existing geotechnical limitations and to maintain, whenever possible, temporary, controlled releases from Townshend Lake. These controlled releases must be sensitive to both flood control and recreational needs at each project. Since Ball Mountain and Townshend Lakes were designed, as a system, to control flood flows on the West and Connecticut Rivers, any construction regulation plan must include both projects. The plan was based on the following:

(1) Construction period July through November (this was determined to have the least impact on flood control and downstream fishery concerns).

(2) Maximum practical cofferdam height of 6 feet.

(3) Twelve-hour advance notice to contractor if anticipated flood control releases from Townshend Lake are expected to exceed the maximum safe working level.

b. Ball Mountain Lake. Recreational activities include: picnicking, hiking, and camping from June through October. Just downstream of Ball Mountain Lake on the West River is a USGS gaging station at Jamaica, Vermont; this gage has a drainage area of 179 square miles. Based on 43 years of record, average monthly flows from June through November are presented in table F-1. Also listed is data on some significant storm events that have occurred in June through November time periods.

c. Townshend Lake. Principal recreation activities at Townshend Lake include: swimming, picnicking, boating, and fishing. About 6.3 miles downstream from Townshend Lake on the West River is a USGS gaging station at Newfane, Vermont; the gage has a drainage area of 308 square miles. Average monthly flows were computed at the Newfane gage and multiplied by a drainage area ratio to more closely represent releases from Townshend Lake. Based on 70 years of record, from 1919 to 1990, average monthly flows from June through November, are presented in table F-2. Also listed are some significant storm events that have occurred during June through November time periods.

TABLE F-1

AVERAGE MONTHLY FLOWS/HISTORIC FLOODS
BALL MOUNTAIN LAKE

Month	Average Monthly Flows (cfs)	Historic Flood Events: Date	Pool Stage (ft.)	Vol (in.)	Max Release (cfs)
June	240	Jun 84	193.1	4.4	4,400
July	130	Jul 73	177.8	3.5	1,500
August	110	Aug 76	165.0	2.8	4,000
September	120	Sep 38*	182.5**	3.7**	4,000**
October	250				
November	350				

* Prior to reservoir construction
** Resulting stage, volume and release rate if project had been operational

TABLE F-2

AVERAGE MONTHLY FLOWS/HISTORIC FLOODS
TOWNSHEND LAKE

Month	Estimated Average Monthly Flows (cfs)	Historic Flood Events Date	Pool Stage (ft.)	Vol (in.)	Max Release (cfs)
June	360	Jun 84	81.8	4.0	7,000
July	184	Jul 73	66.1	2.3	4,000
August	140	Aug 76	48.5	1.1	5,200
September	181	Sep 38*	80.8**	3.7**	7,000**
October	283				
November	497				

* Prior to reservoir construction
** Resulting stage, volume and release rate if project had been operational

d. Regulation Plan

(1) General. The proposed plan for reservoir regulation during instream construction of the fish passage facility includes controlling releases from both projects by utilizing their available storage capacities. A maximum controlled release rate of 1,500 cfs from Townshend Lake was selected based on a limited cofferdam height as determined by GED. Ball Mountain releases were then determined by multiplying the releases at Townshend Lake by the ratio of each projects drainage area, resulting in a maximum controlled rate of 1,000 cfs. This proportion of releases closely resembles normal regulation procedures and is in conformance with the West River watershed's response during a runoff event. It should also be noted that reservoir drawdown at each project will not exceed the rates currently maintained during normal flood control operations (Townshend Lake - 10 feet/day; Ball Mountain Lake - 20 feet/day).

(2) Ball Mountain Lake. The following regulation plan is proposed for this project during the July through November construction period.

(a) Reduce pool stage from a normal 65-foot depth to a 25-foot depth and maintain throughout the construction period. This results in an additional 0.25 inch of storage, allowing greater regulation flexibility.

(b) Limit controlled releases to about 700 cfs during working hours and 1,000 cfs during nonworking hours.

(c) As a result of limiting controlled releases to 1,000 cfs, water will be stored within the reservoir when inflows exceeds 1,000 cfs. In order to maintain releases at 1,000 cfs or less, water may be stored from a 25 to a 115-foot pool, utilizing about 9,200 acre-feet of storage (about 1.0 inch of runoff from drainage area). When the pool rises over 115 feet, normal flood control regulation procedures would take over and releases greater than 1,000 cfs may be required. Normal flood control procedures would remain in effect until the pool is lowered to the 25-foot stage (under normal flood control regulation procedures it would take approximately 5 days to lower the pool from 115 to 25 feet). Once the pool is lowered to a 25-foot stage, controlled releases will again be limited to 700 cfs and 1,000 cfs during working and nonworking hours, respectively.

(d) In an effort to support downstream fish and other aquatic life, a minimum release rate of 90 cfs or inflow, whichever is less, will be maintained whenever possible. In addition, it is recommended that in order to sustain the downstream aquatic environment, releases should not be abruptly reduced from about 200 cfs to normal inflow conditions. At 200 cfs, reductions in releases back to normal inflow conditions, should be "stepped down" over a 12-to 24-hour period. This procedure will be followed whenever possible.

(3) Townshend Lake. The following regulation plan is proposed for Townshend Lake during the July through November construction period.

(a) Maintain normal 21-foot pool stage.

(b) Limit controlled releases to about 1,000 cfs during working hours and 1,500 cfs during nonworking hours. At a 1,500 cfs release rate, flows would pass the cofferdam at a depth of 6 feet; however, for safety reasons, flows should not exceed a 4-1/2-foot depth (approximately 1,000 cfs) during working hours; thereby, maintaining 1-1/2 feet of freeboard on the cofferdam. If flows are expected to encroach into this freeboard range, the contractor will be notified and advised to vacate the work area.

(c) As a result of limiting controlled releases to 1,500 cfs, water will be stored within the reservoir when inflows exceed 1,500 cfs. When this occurs, water may be stored from a 21-foot to a 47-foot pool, utilizing about

5,700 acre-feet of storage (about 1.0 inch of runoff from the net drainage area of 106 square miles), in order to maintain releases at 1,500 cfs, or less. When the pool rises over 47 feet, normal flood control regulation procedures would take over and releases greater than 1,500 cfs may be required. If releases above 1,500 cfs become necessary the contractor will be given a 12-hour notice to vacate the work area. Normal flood control procedures would remain in effect until the pool is lowered to the 21-foot stage (under normal flood control regulation procedures, it would take approximately 5 days to lower the pool from 47 to 21 feet). Once the pool is lowered to a 21-foot stage, controlled releases will again be limited to 1,000 and 1,500 cfs during working and nonworking hours, respectively.

(d) In an effort to support downstream fish and other aquatic life, a minimum release rate of 90 cfs or inflow, whichever is less, will be maintained whenever possible. In addition, it is recommended that in order to sustain the downstream aquatic environment, releases should not be abruptly reduced from 200 cfs to normal inflow conditions. At 200 cfs, reductions in releases back to normal inflow conditions, should be "stepped down" over a 12 to 24-hour period. This procedure will be followed whenever possible.

e. Analysis. The reservoir regulation plan for construction of the fish passage facility was developed considering the following parameters: (1) flow data at USGS gaging stations located downstream of each project, (2) analysis of historic flood events which have occurred within the June through November timeframe, and (3) a maximum cofferdam height of 6 feet.

(1) Flow duration data was computed, downstream of each project, for June through November conditions. This data is shown in table F-3. Analysis of the flow duration data shows that releases of 1,000 and 1,500 cfs from Ball Mountain and Townshend Lakes, respectively, are quite adequate to maintain flood control regulation during average conditions, as well as provide an adequate flow regime in support of the construction schedule. Only about 5 percent of the time are daily flows in excess of 1,000 and 1,500 cfs experienced. Over the proposed 183-day construction period, this 5 percent equates to a period of about 10 days that average flows may exceed the limited channel capacities. Of course, a "wet" year may include more days of high flow and a "dry" year much less.

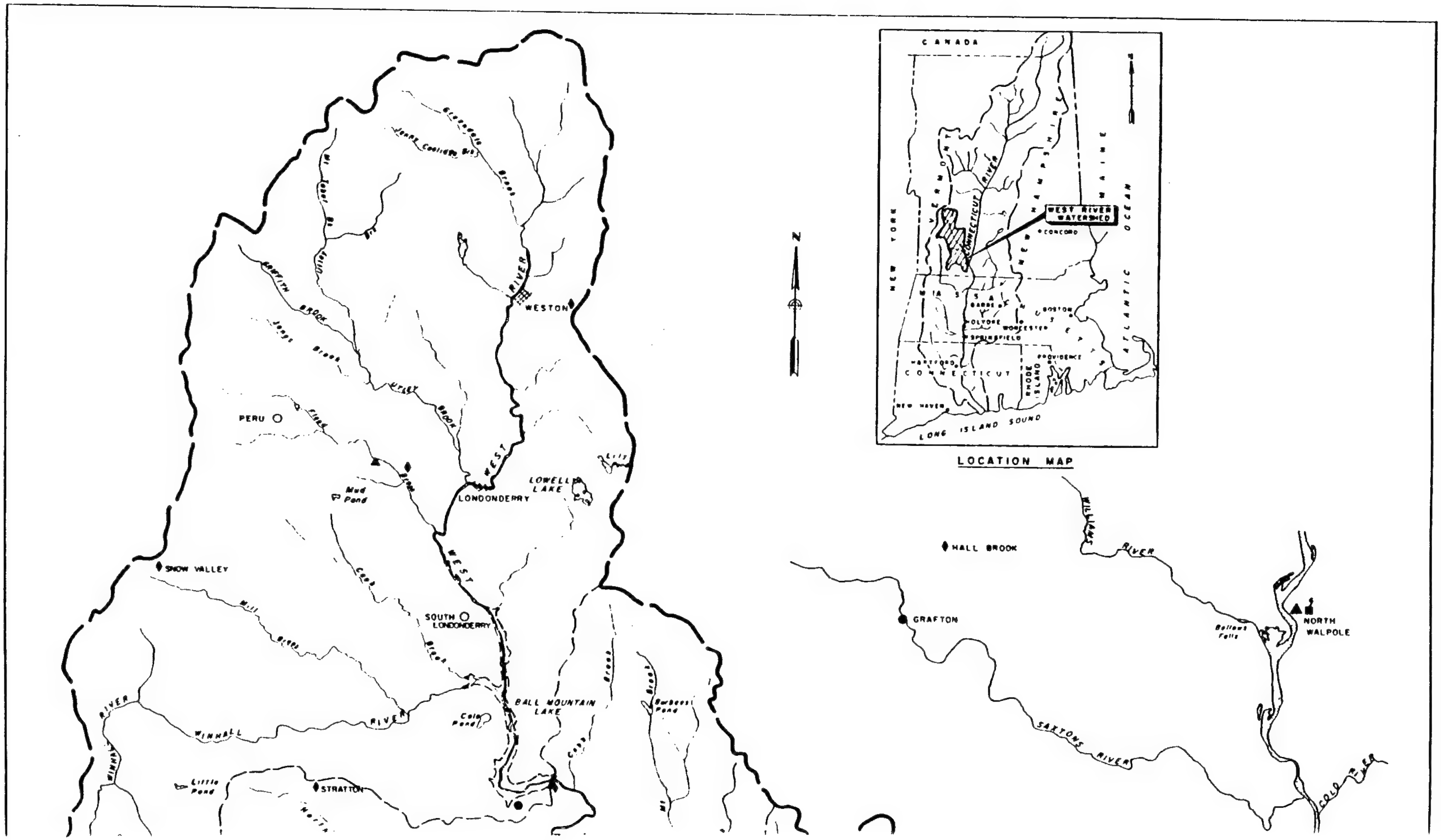
TABLE F-3

AVERAGE DAILY FLOW DURATION
WEST RIVER VERMONT
(June - November)

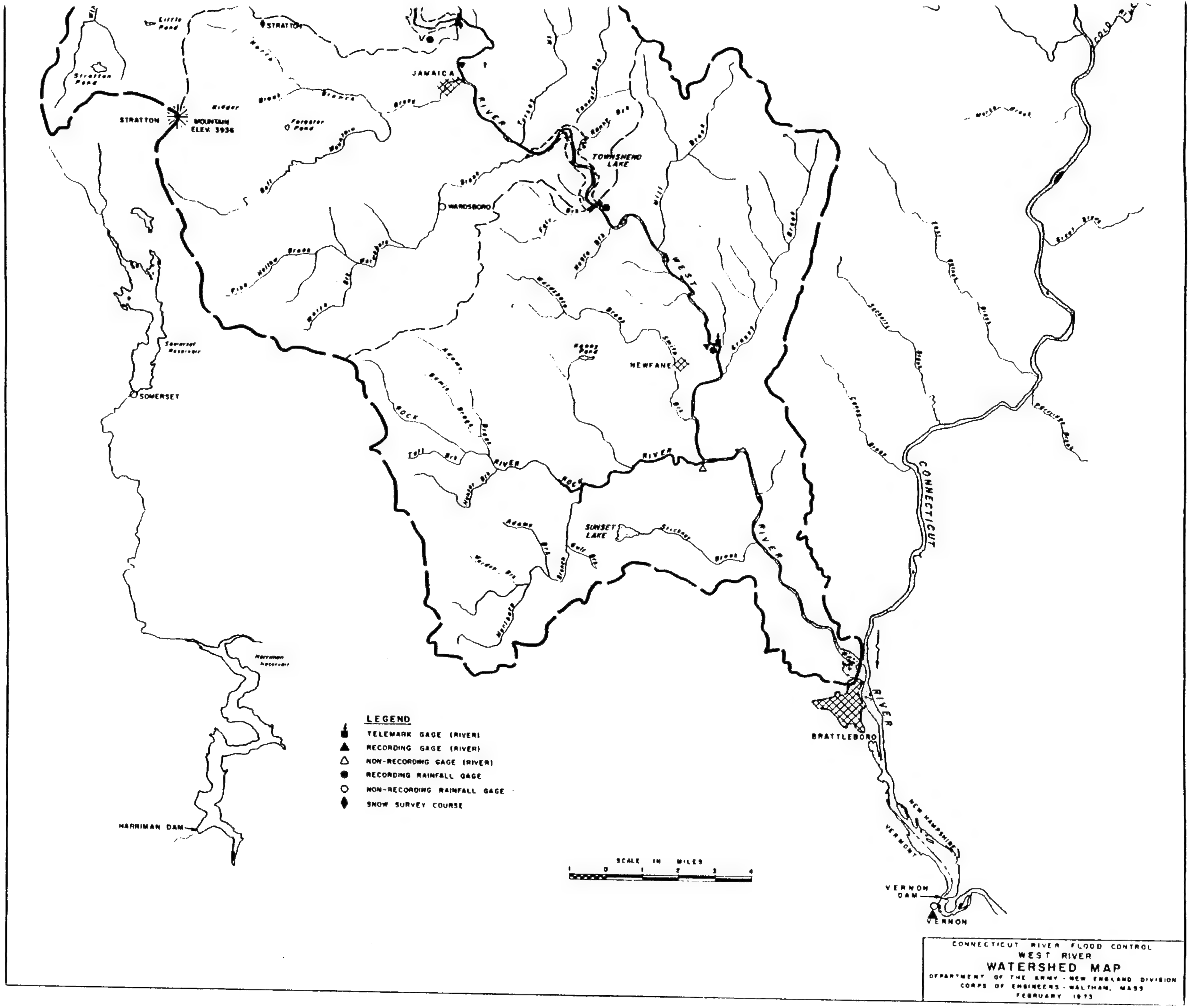
Percent of Time Flow Equal to or Greater	Ball Mountain Discharge (cfs)	Townshend Lake Discharge (cfs)
95	20	32
90	29	43
75	46	73
70	53	84
50	94	140
25	228	322
10	528	723
05	840	1,200
03	1,100	1,800

(2) Since floods can occur during any season in New England, it is necessary to insure the flood control effectiveness of Ball Mountain and Townshend Lakes during flood events while maintaining a release rate favorable to construction. An analysis of tables F-1 and F-2 indicates that even during the historic and high water events listed, there would still have been adequate storage for flood control even if the reservoirs were initially filled to a volume equivalent to 1.0 inch of runoff. For example, utilizing about 4.0 inches of storage during the June 1984 event, Townshend Lake would have had about 0.8 inch of storage remaining if the reservoir was filled initially to a 47-foot pool stage.

(3) A high flow duration frequency analysis for the gaging stations downstream of Ball Mountain and Townshend Lakes was also performed. This analysis revealed, with controlled releases of 1,000 and 1,500 cfs and the flexibility of storing about 1.0 inch of runoff, a level of protection equivalent to approximately a 7-day storm duration having a recurrence interval of about 3 years, would be realized. This is believed adequate because the proposed fish passage facility consists mainly of a concrete slab and damage would be relatively minor if the cofferdam were overtopped. If storm events greater than this magnitude were to occur, normal reservoir regulation procedures would be implemented and the contractor would be directed to remove all equipment, materials, etc. from the work area. Once this is completed, normal flood control operations would begin and the cofferdam would be overtopped. With all equipment and materials removed from the channel, the resulting damage should be minimal.


LOCATION MAP
CANADA
NEW YORK
VERMONT
NEW HAMPSHIRE
MAINE
MASS.
CONNECTICUT
RHODE ISLAND
ATLANTIC OCEAN
LONG ISLAND SOUND
CONNECTICUT RIVER
WEST RIVER WATERSHED
CONCORD
BOSTON
WORCESTER
SPRINGFIELD
HOLYOKE
HARTFORD
NEW HAVEN
PROVIDENCE
N
WESTON
WEST RIVER
LONDONDERRY
LOWELL LAKE
SOUTH LONDONDERRY
BALL MOUNTAIN LAKE
PERU
Mud Pond
SNOW VALLEY
STRATTON
Little Pond
WINHALL RIVER
Cobb Brook
Mill Brook
Griffith Brook
Utley Brook
Greendale Brook
Cold Pond
HALL BROOK
GRAFTON
WILLIAMS RIVER
SAXTONS RIVER
NORTH WALPOLE
Bellows Falls

2


CONNECTICUT RIVER FLOOD CONTROL
WEST RIVER
WATERSHED MAP
DEPARTMENT OF THE ARMY - NEW ENGLAND DIVISION
CORPS OF ENGINEERS - WALTHAM, MASS
FEBRUARY 1973
LEGEND
TELEMARK GAGE (RIVER)
RECORDING GAGE (RIVER)
NON-RECORDING GAGE (RIVER)
RECORDING RAINFALL GAGE
NON-RECORDING RAINFALL GAGE
SNOW SURVEY COURSE
SCALE IN MILES
1 0 1 2 3 4
STRATTON
MOUNTAIN
ELEV. 3936
JAMAICA
WARDSBORO
TOWNSHEND LAKE
NEWFANE
SUNSET LAKE
BRATTLEBORO
SOMERSET
HARRIMAN DAM
VERNON DAM
VERNON
WEST
RIVER
ROCK
CONNECTICUT
NEW HAMPSHIRE
VERMONT
Stratton Pond
Little Pond
Forester Pond
Somerset Reservoir
Harriman Reservoir

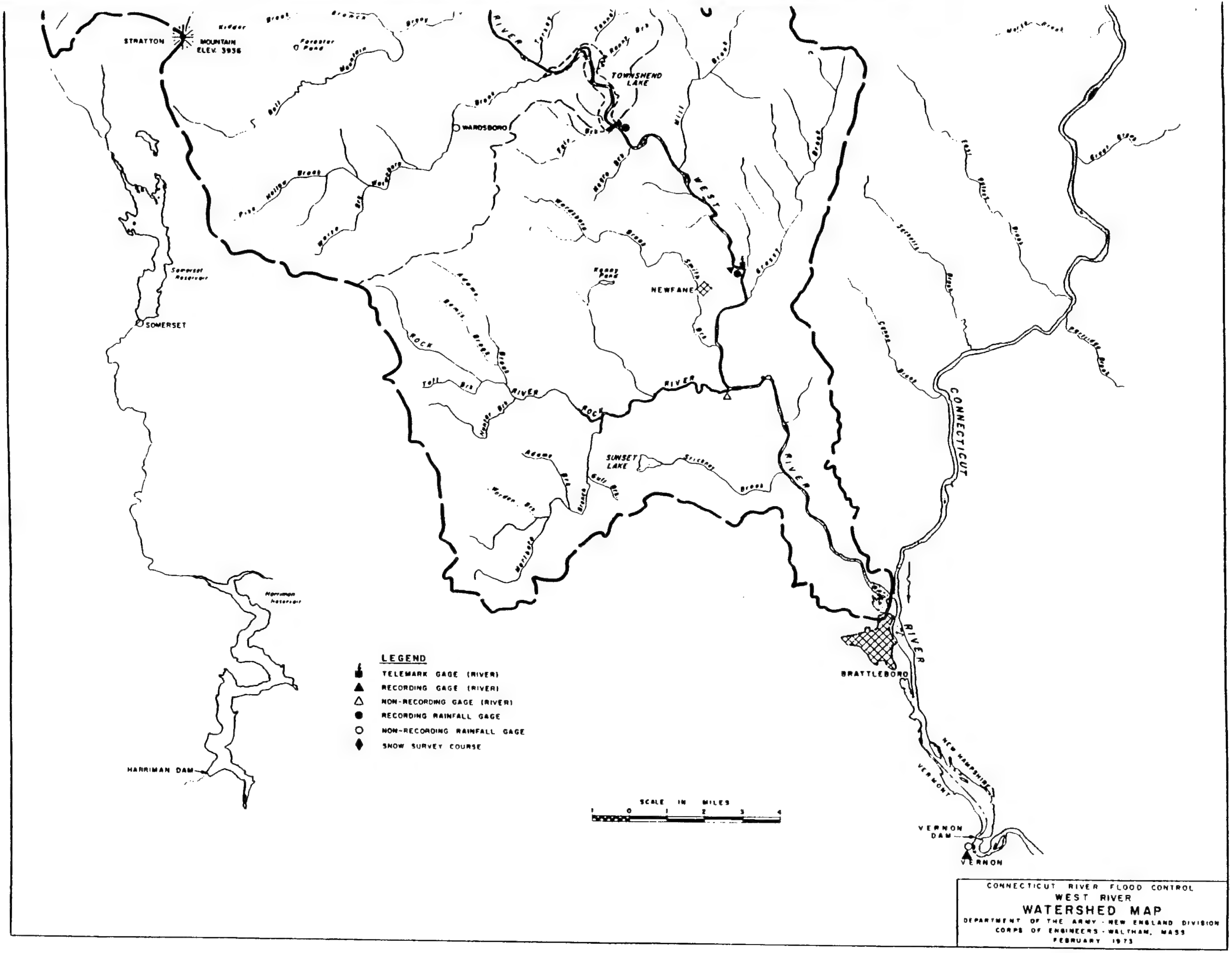

STRATTON MOUNTAIN ELEV. 3936
TOWNSHEND LAKE
WARDSBORO
NEWFANE
SOMERSET
Somerset Reservoir
Harriman Reservoir
HARRIMAN DAM
SUNSET LAKE
WEST
RIVER
ROCK
CONNECTICUT
BRATTLEBORO
NEW HAMPSHIRE
VERMONT
VERNON DAM
VERNON
LEGEND
TELEMARK GAGE (RIVER)
RECORDING GAGE (RIVER)
NON-RECORDING GAGE (RIVER)
RECORDING RAINFALL GAGE
NON-RECORDING RAINFALL GAGE
SNOW SURVEY COURSE
SCALE IN MILES
1 0 1 2 3 4
CONNECTICUT RIVER FLOOD CONTROL
WEST RIVER
WATERSHED MAP
DEPARTMENT OF THE ARMY - NEW ENGLAND DIVISION
CORPS OF ENGINEERS - WALTHAM, MASS
FEBRUARY 1973

PLATE F-1

PERTINENT DATA
BALL MOUNTAIN LAKE

LOCATION — West River, Jamaica and Londonderry, Vermont

DRAINAGE AREA — 172 square miles

STORAGE USES
- Flood Control
- Recreation

RESERVOIR STORAGE

	Elevation msl	Stage feet	Area acres	Capacity Acre-Feet	Capacity Inches on Drainage Area
Inlet Elevation	805.5	0	0	0	0
Permanent Pool	830.5	25.0	20	.240	0.05
Conservation Pool	870.5	65.0	75	2,000 (net)	0.22(net)
Spillway Crest	1017.0	211.5	810	52,450 (net)	5.7 (net)
Maximum Surcharge	1047.0	241.5	1,160	29,550 (net)	3.2 (net)
Top of Dam	1052.0	246.5			

EMBANKMENT FEATURES

Type	Rolled earth fill, rock slope protection, impervious core
Length (ft)	915
Top Width (ft)	20
Top Elevation (ft msl)	1,052.0
Height (ft)	265
Volume (cy)	2,311,000
Dike	None

SPILLWAY

Location	Right-West Abutment
Type	Uncontrolled, ogee weir and chute spillway in rock
Crest Length (ft)	235
Crest Elevation (ft msl)	1,017.0
Surcharge (ft)	30.0
Design Head (ft)	30.0
Maximum Discharge Capacity (cfs)	150,000

OUTLET WORKS

Type	Circular concrete tunnel
Tunnel Inside Diameter (ft)	13.5
Tunnel Length (ft)	864
Service Gate Type	Hydraulic slide
Service Gate Size	Three, 5'-8" x 10'-0"
Emergency Gate Type	None (stoplogs only)
Downstream Channel Capacity (cfs)	[illegible]

Maximum Discharge Capacity (cfs)	150,000

OUTLET WORKS

Type	Circular concrete tunnel
Tunnel Inside Diameter (ft)	13.5
Tunnel Length (ft)	864
Service Gate Type	Hydraulic slide
Service Gate Size	Three, 5'-8" x 10'-0"
Emergency Gate Type	None (stoplogs only)
Downstream Channel Capacity (cfs)	5,000±
Maximum Discharge Capacity Spillway Crest Elevation (cfs)	10,400
Stilling Basin	None

PERMANENT POOL

Length (ft)	3,600
Shoreline Length (ft)	7,500
Area (acres)	20

CONSERVATION POOL

Length (ft)	9,700
Shoreline Length (ft)	19,500
Area (acres)	75

LAND ACQUISITION	El. (ft msl)	Stage (ft)	Area (acres)
Fee Taking	985	179.5	965
Easement	1,057	251.5	262
Clearing	870±	64.5	

MAXIMUM POOL OF RECORD

Date	April 24, 1969
Stage (ft)	197.8
Percent Full	82

SPILLWAY DESIGN FLOOD

	Original Design 1956	1967 Analysis
Peak Inflow (cfs)	190,000	190,000
Peak Outflow (cfs)	162,800	162,800*

* 150,000 Spillway Discharge; 12,800 Conduit Discharge

UNIT RUNOFF

One Inch Runoff (acre-ft)	9,180

OPERATING TIME

Open/Close all Gates	10 min. (Manual Operation: 90 turns/ft)

PROJECT COST (thru FY71) $10,585,000

DATE OF COMPLETION October 1961

MAINTAINED BY New England Division, Corps of Engineers

Maximum Discharge Capacity			
Spillway Crest Elevation (cfs)	10,400		
Stilling Basin	None		
PERMANENT POOL			
Length (ft)	3,600		
Shoreline Length (ft)	7,500		
Area (acres)	20		
CONSERVATION POOL			
Length (ft)	9,700		
Shoreline Length (ft)	19,500		
Area (acres)	75		
LAND ACQUISITION	El. (ft msl)	Stage (ft)	Area (acres)
Fee Taking	985	179.5	965
Easement	1,057	251.5	262
Clearing	870±	64.5	
MAXIMUM POOL OF RECORD			
Date	April 24, 1969		
Stage (ft)	197.8		
Percent Full	82		
SPILLWAY DESIGN FLOOD			
	Original Design 1956	1967 Analysis	
Peak Inflow (cfs)	190,000	190,000	
Peak Outflow (cfs)	162,800	162,800*	

* 150,000 Spillway Discharge; 12,800 Conduit Discharge

UNIT RUNOFF	
One Inch Runoff (acre-ft)	9,180
OPERATING TIME	
Open/Close all Gates	10 min. (Manual Operation: 90 turns/ft)
PROJECT COST (thru FY71)	$10,585,000
DATE OF COMPLETION	October 1961
MAINTAINED BY	New England Division, Corps of Engineers

3

PERTINENT DATA
TOWNSHEND LAKE

LOCATION	West River, Townshend and Jamaica, Vermont
DRAINAGE AREA	106 square miles (Net), 278 square miles (Total)

STORAGE USES
- Flood Control
- Recreation

RESERVOIR STORAGE

	Elevation msl	Stage feet	Area acres	Capacity Acre-Feet	Capacity Inches on Drainage Area
Inlet Elevation	457.0	0	0	0	0
Recreation Pool	478	21	95	800	0.14
Spillway Crest	553.0	96.0	735	32,900 (net)	5.81 (net)
Maximum Surcharge	578.0	121.0	980	20,600 (net)	3.6 (net)
Top of Dam	583.0	126.0			

EMBANKMENT FEATURES

Type	Rolled earth fill, rock slope protection, impervious core
Length (ft)	1,700
Top Width (ft)	20
Top Elevation (ft msl)	583.0
Height (ft)	133
Volume (cy)	1,420,000
Dike	None

SPILLWAY

Location	Left-East Abutment
Type	Uncontrolled, ogee weir L-shaped side channel spillway
Crest Length (ft)	439
Crest Elevation (ft msl)	553.0
Surcharge (ft)	25.0
Design Head (ft)	25.0
Maximum Discharge Capacity (cfs)	201,000

OUTLET WORKS

Type	Horseshoe-shaped concrete conduit
Tunnel Inside Diameter (ft)	20.5
Tunnel Length (ft)	360
Service Gate Type	Vertical lift (wheel)
Service Gate Size	Three, 7'-6" x 17'-0"
Emergency Gate Type	Bulkhead

(2)

Service Gate Size	Three, 7'-6" x 17'-0"
Emergency Gate Type	Bulkhead
Emergency Gate Size	One, 10'-6" x 22'-6"
Downstream Channel Capacity	9,000±
Maximum Discharge Capacity Spillway Crest Elevation (cfs)	22,100
Stilling Basin	None

RECREATION WEIR

Type	U-shaped concrete weir
Location	Upstream of center gate
Weir Length (ft)	53
Stoplogs	None
Crest Stage (ft)	21.0
Recreation Pool Stage (ft)	21 (approx.)
Manually Operated Gate	2' x 3'

RECREATION POOL

Length (ft)	6,400
Shoreline Length (ft)	18,000
Area (acres)	95

LAND ACQUISITION

	El. (ft msl)	Stage (ft)	Area (acres)
Fee Taking	525	68	1,010
Easement	563	106	209
Clearing	481±	24	

MAXIMUM POOL OF RECORD

Date	April 29, 1969
Stage (ft)	80.3
Percent Full	65

SPILLWAY DESIGN FLOOD

	Original Design 1956	1967 Analysis
Peak Inflow (cfs)	228,000	228,000
Peak Outflow (cfs)	224,000	224,000*

* 201,000 Spillway Discharge; 23,000 Conduit Discharge

UNIT RUNOFF

One Inch Runoff (acre-ft)	5,650

OPERATING TIME

Open/Close all Gates	5 min. (Manual Operation: 90 turns/ft)

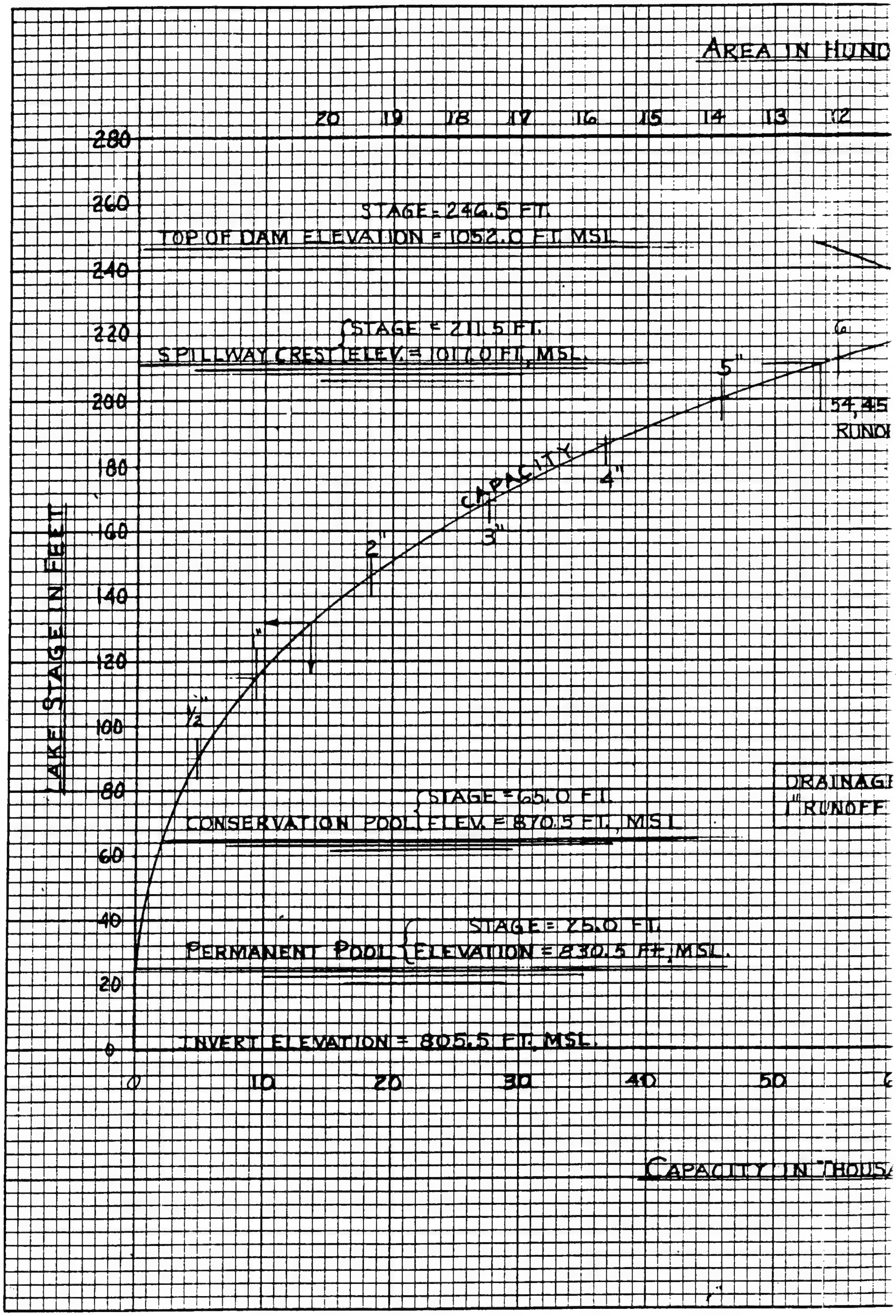
PROJECT COST (thru FY71)	$7,392,400
DATE OF COMPLETION	June 1961
MAINTAINED BY	New England Division, Corps of Engineers

Maximum Discharge Capacity			
Spillway Crest Elevation (cfs)	22,100		
Stilling Basin	None		
RECREATION WEIR			
Type	U-shaped concrete weir		
Location	Upstream of center gate		
Weir Length (ft)	53		
Stoplogs	None		
Crest Stage (ft)	21.0		
Recreation Pool Stage (ft)	21 (approx.)		
Manually Operated Gate	2' x 3'		
RECREATION POOL			
Length (ft)	6,400		
Shoreline Length (ft)	18,000		
Area (acres)	95		
LAND ACQUISITION	El. (ft msl)	Stage (ft)	Area (acres)
Fee Taking	525	68	1,010
Easement	563	106	209
Clearing	481±	24	
MAXIMUM POOL OF RECORD			
Date	April 29, 1969		
Stage (ft)	80.3		
Percent Full	65		
SPILLWAY DESIGN FLOOD	Original Design 1956	1967 Analysis	
Peak Inflow (cfs)	228,000	228,000	
Peak Outflow (cfs)	224,000	224,000*	

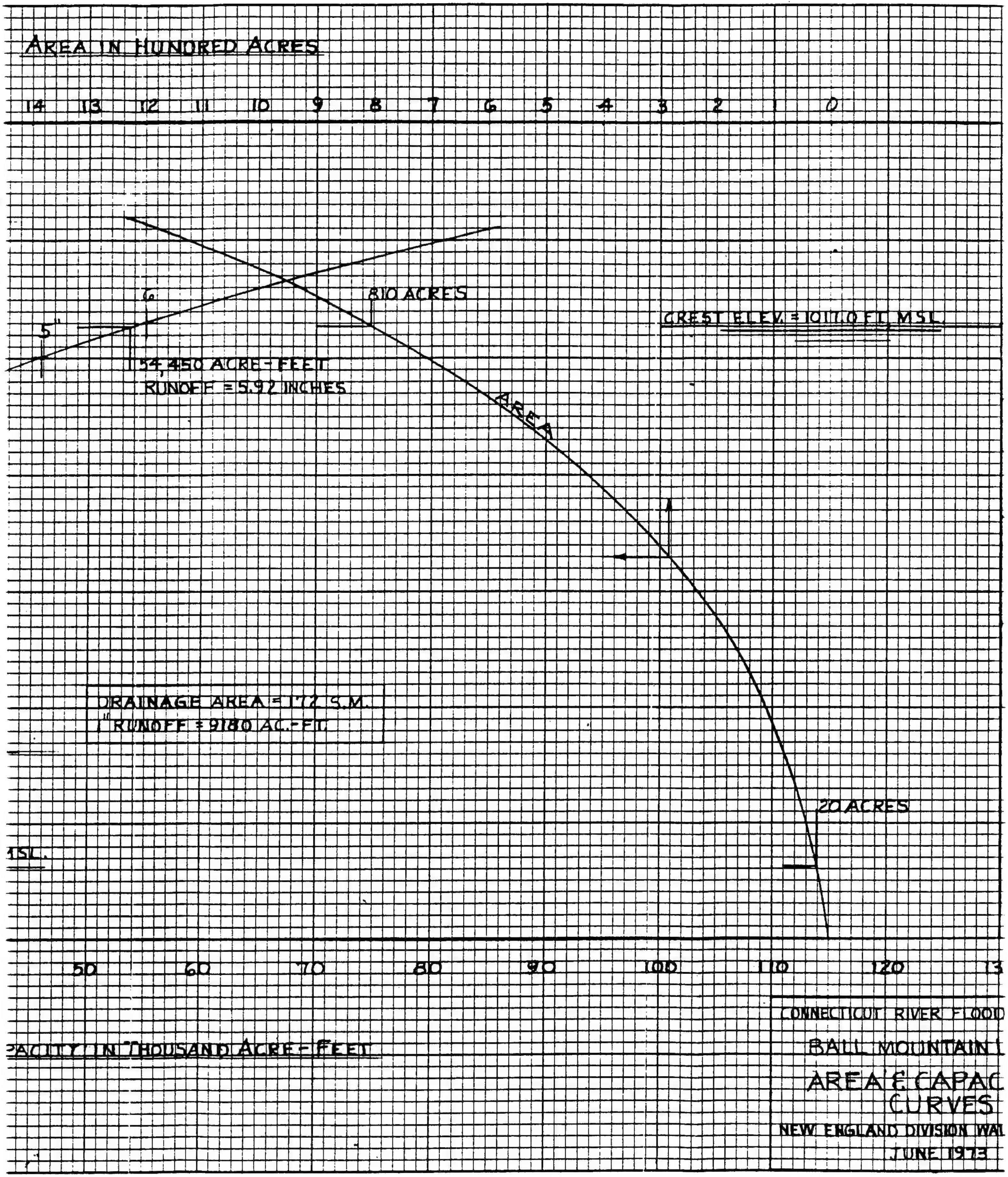
* 201,000 Spillway Discharge; 23,000 Conduit Discharge

UNIT RUNOFF	
One Inch Runoff (acre-ft)	5,650
OPERATING TIME	
Open/Close all Gates	5 min. (Manual Operation: 90 turns/ft)
PROJECT COST (thru FY71)	$7,392,400
DATE OF COMPLETION	June 1961
MAINTAINED BY	New England Division, Corps of Engineers

PLATE F-3

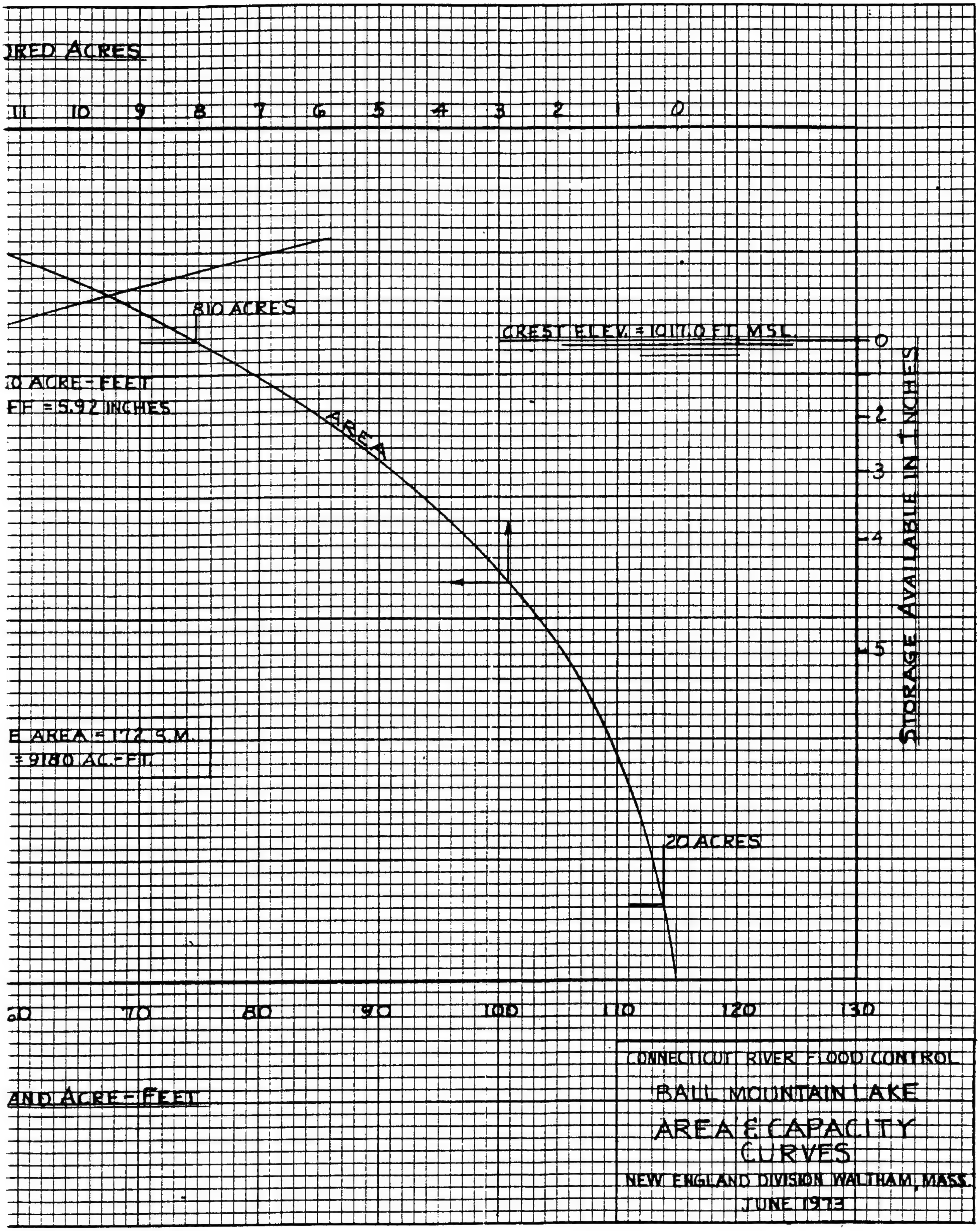

AREA IN HUND
20 19 18 17 16 15 14 13 12
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
STAGE = 246.5 FT.
TOP OF DAM ELEVATION = 1052.0 FT. MSL
STAGE = 211.5 FT.
SPILLWAY CREST ELEV. = 1017.0 FT. MSL.
6
5"
54,45
RUNOI
CAPACITY
4"
3"
2"
½"
DRAINAGE
1" RUNOFF
STAGE = 65.0 FT.
CONSERVATION POOL ELEV. = 870.5 FT. MSL
STAGE = 25.0 FT.
PERMANENT POOL ELEVATION = 830.5 FT. MSL.
INVERT ELEVATION = 805.5 FT. MSL.
0 10 20 30 40 50
LAKE STAGE IN FEET
CAPACITY IN THOUS

①


AREA IN HUNDRED ACRES
14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
6
5"
810 ACRES
CREST ELEV. = 1017.0 FT. MSL.
54,450 ACRE-FEET
RUNOFF = 5.92 INCHES
AREA
DRAINAGE AREA = 172 S.M.
1" RUNOFF = 9180 AC.-FT.
20 ACRES
1SL.
50 60 70 80 90 100 110 120 13
PACITY IN THOUSAND ACRE-FEET
CONNECTICUT RIVER FLOOD
BALL MOUNTAIN
AREA & CAPAC
CURVES
NEW ENGLAND DIVISION WA
JUNE 1973

PL

(2)



CONNECTICUT RIVER FLOOD CONTROL

BALL MOUNTAIN LAKE

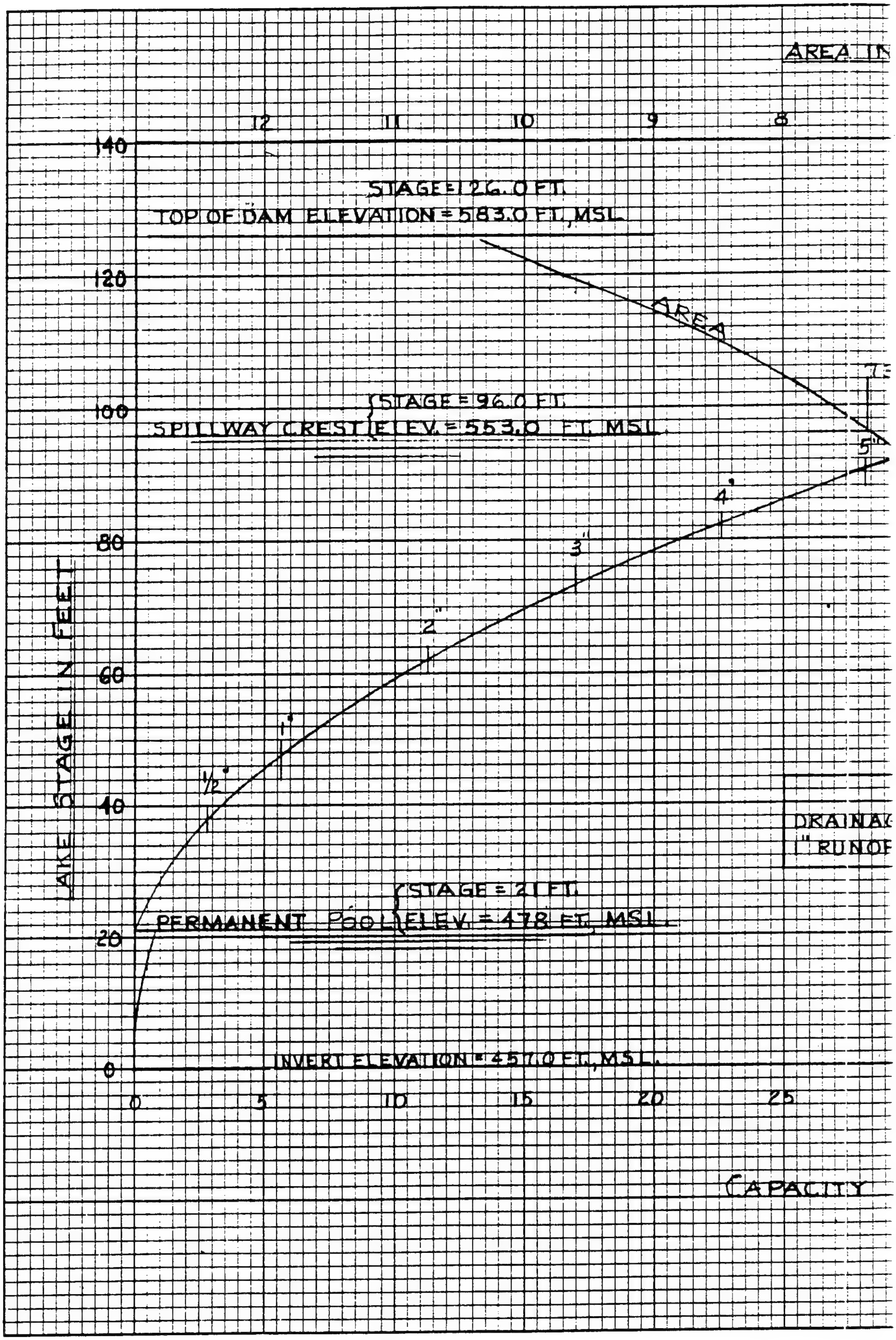
AREA & CAPACITY CURVES

NEW ENGLAND DIVISION WALTHAM, MASS.

JUNE 1973

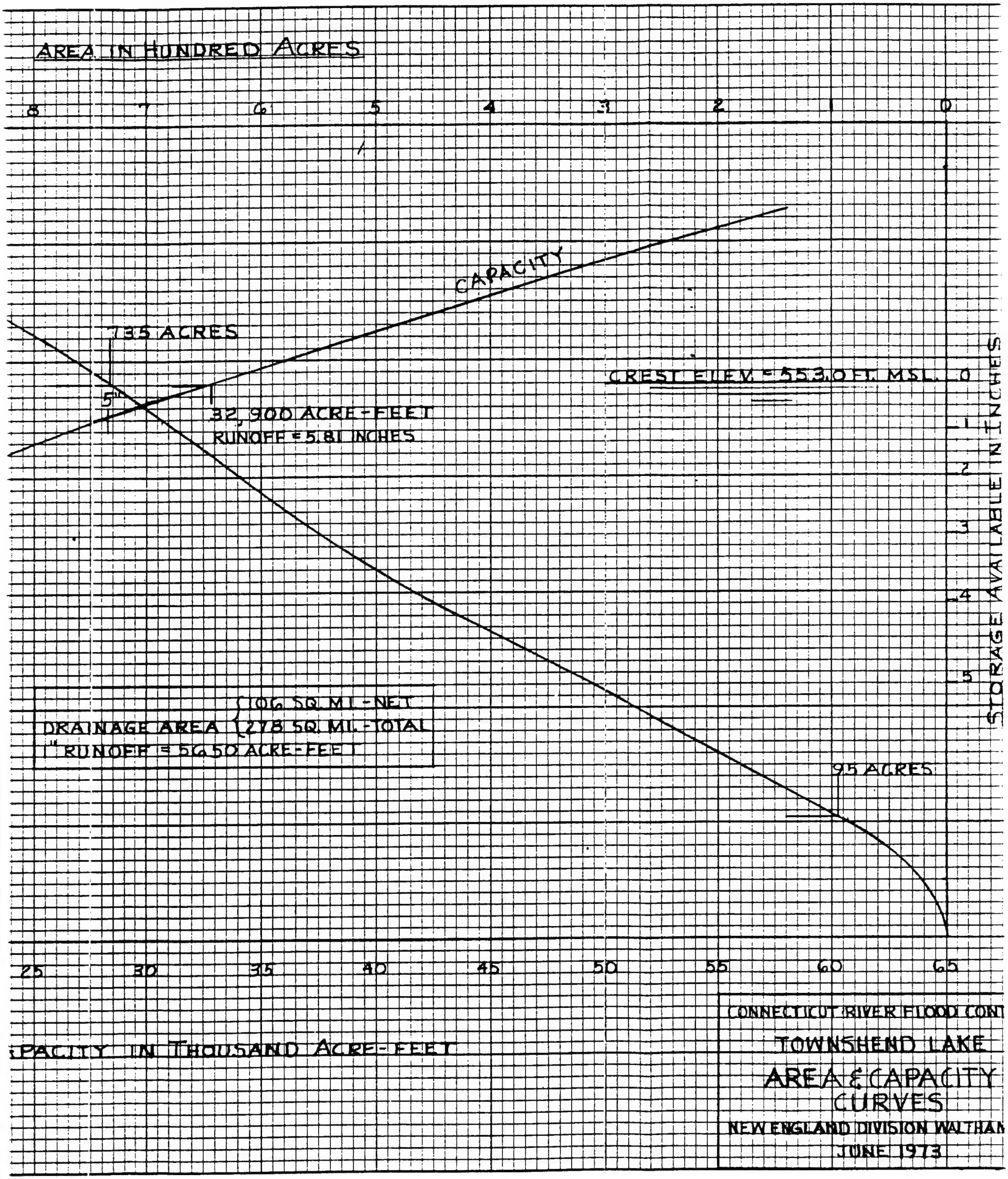
PLATE F-4

3



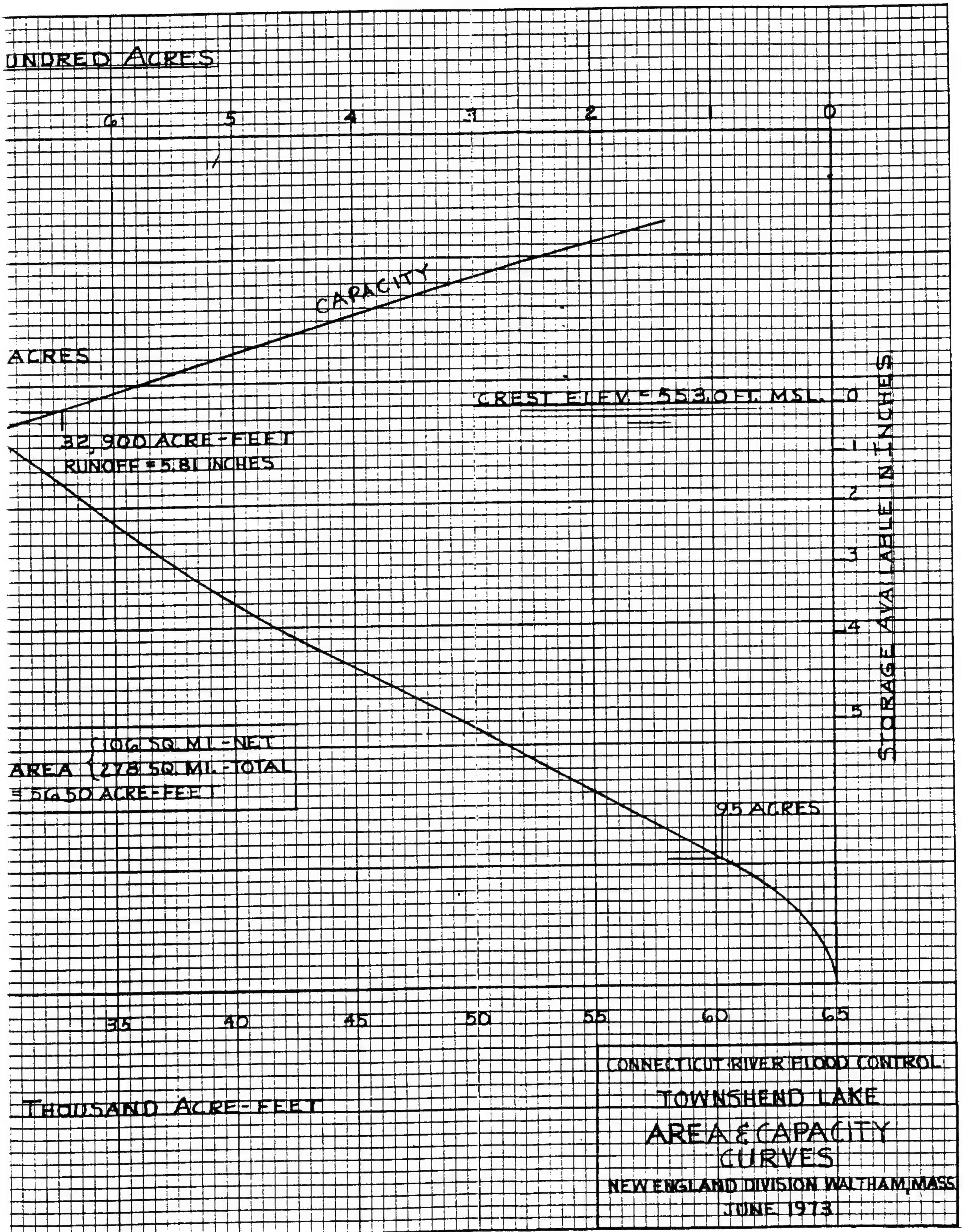
AREA IN
12
11
10
9
8
140
STAGE=126.0 FT.
TOP OF DAM ELEVATION = 583.0 FT. MSL.
120
AREA
100
STAGE = 96.0 FT.
SPILLWAY CREST ELEV. = 553.0 FT. MSL.
80
60
40
20
0
LAKE STAGE IN FEET
½"
1"
2"
3"
4"
5"
STAGE = 21 FT.
PERMANENT POOL ELEV. = 478 FT. MSL.
INVERT ELEVATION = 457.0 FT. MSL.
0
5
10
15
20
25
CAPACITY
DRAINAG
1" RUNOF

(1)


AREA IN HUNDRED ACRES
8
7
6
5
4
3
2
1
0
CAPACITY
735 ACRES
5"
32,900 ACRE-FEET
RUNOFF = 5.81 INCHES
CREST ELEV. = 553.0 FT. MSL.
0
1
2
3
4
5
STORAGE AVAILABLE IN INCHES
DRAINAGE AREA {106 SQ. MI. - NET
278 SQ. MI. - TOTAL
1" RUNOFF = 5650 ACRE-FEET
95 ACRES
25
30
35
40
45
50
55
60
65
PACITY IN THOUSAND ACRE-FEET
CONNECTICUT RIVER FLOOD CONT
TOWNSHEND LAKE
AREA & CAPACITY
CURVES
NEW ENGLAND DIVISION WALTHAM
JUNE 1973

PLATE

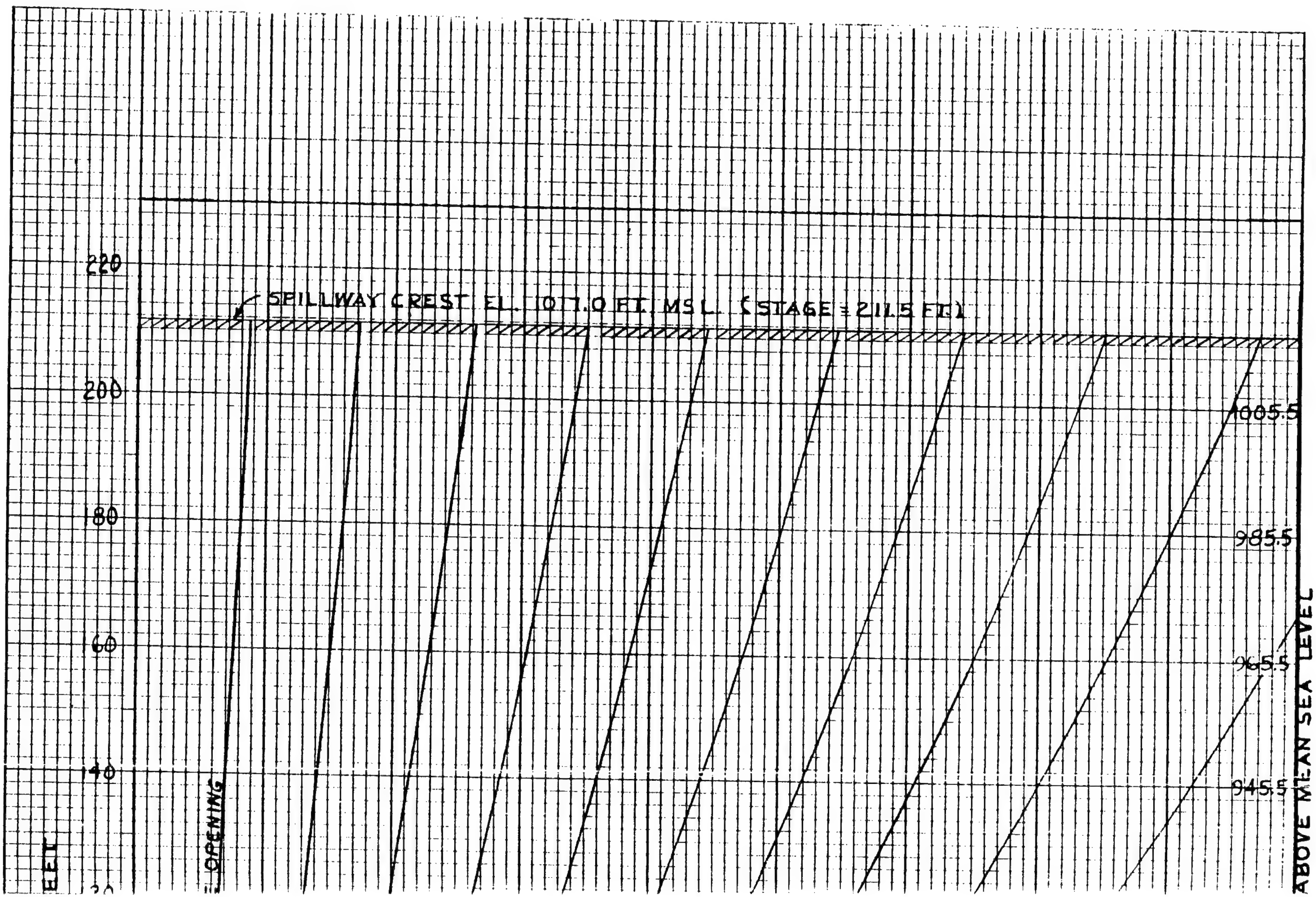
②



UNDRED ACRES
6
5
4
3
2
1
0
CAPACITY
ACRES
CREST ELEV. = 553.0 FT. MSL.
32,900 ACRE-FEET
RUNOFF = 5.81 INCHES
STORAGE AVAILABLE IN INCHES
0
1
2
3
4
5
AREA {106 SQ. MI.-NET
278 SQ. MI.-TOTAL
= 5650 ACRE-FEET
95 ACRES
35
40
45
50
55
60
65
THOUSAND ACRE-FEET
CONNECTICUT RIVER FLOOD CONTROL
TOWNSHEND LAKE
AREA & CAPACITY
CURVES
NEW ENGLAND DIVISION WALTHAM, MASS.
JUNE 1973

PLATE F-5

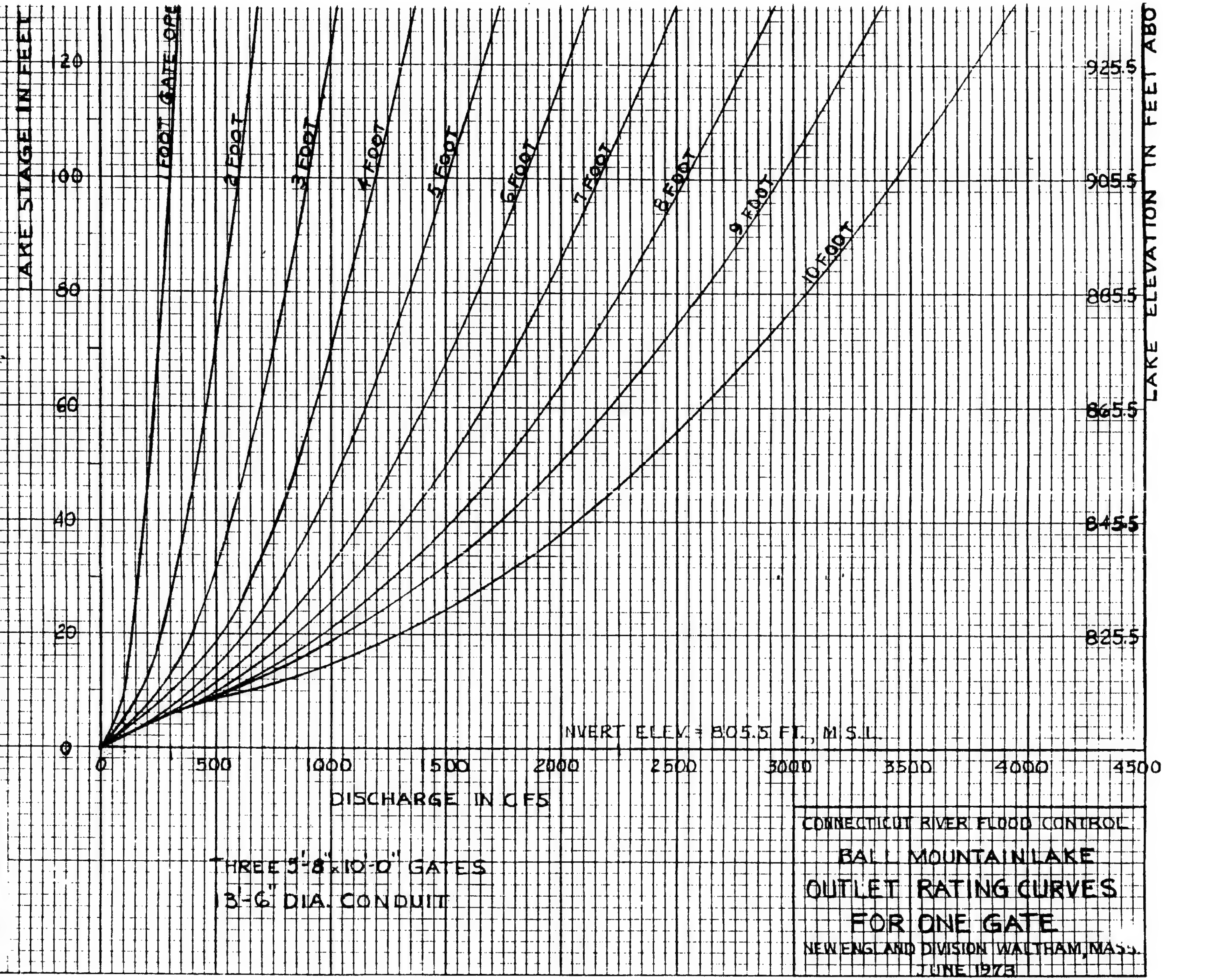
3



SPILLWAY CREST EL. 1017.0 FT. MSL. (STAGE = 211.5 FT.)
220
200
180
160
140
1005.5
985.5
965.5
945.5
OPENING
EET
ABOVE MEAN SEA LEVEL

①

②



LAKE STAGE IN FEET
LAKE ELEVATION IN FEET ABO
925.5
905.5
885.5
865.5
845.5
825.5
20
100
80
60
40
20
0
1 FOOT GATE OPE
2 FOOT
3 FOOT
4 FOOT
5 FOOT
6 FOOT
7 FOOT
8 FOOT
9 FOOT
10 FOOT
INVERT ELEV. = 805.5 FT., M.S.L.
0
500
1000
1500
2000
2500
3000
3500
4000
4500
DISCHARGE IN CFS
THREE 5'-8"x10'-0" GATES
13'-6" DIA. CONDUIT
CONNECTICUT RIVER FLOOD CONTROL
BALL MOUNTAIN LAKE
OUTLET RATING CURVES
FOR ONE GATE
NEW ENGLAND DIVISION WALTHAM, MASS.
JUNE 1973

PLATE F-6

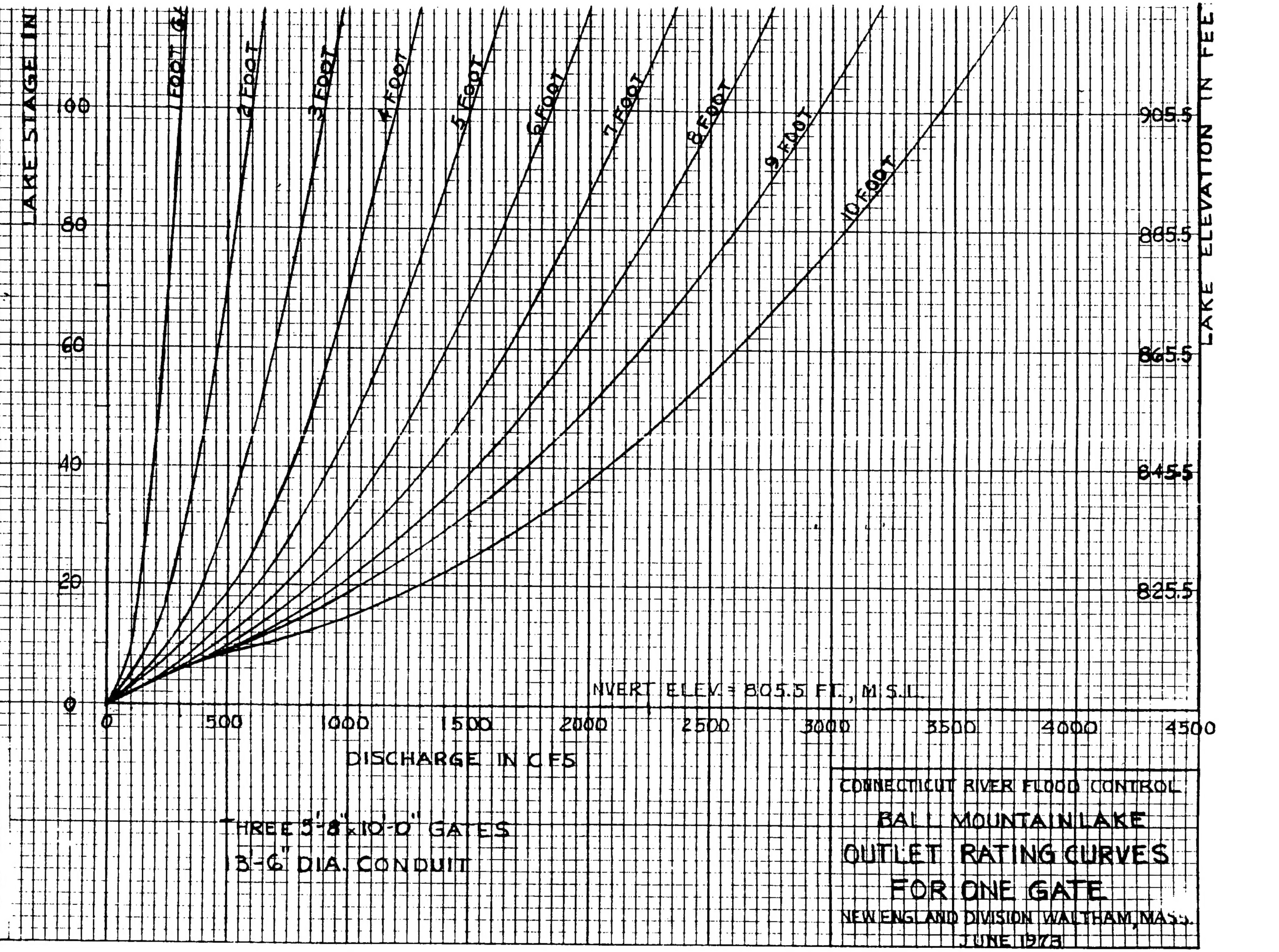
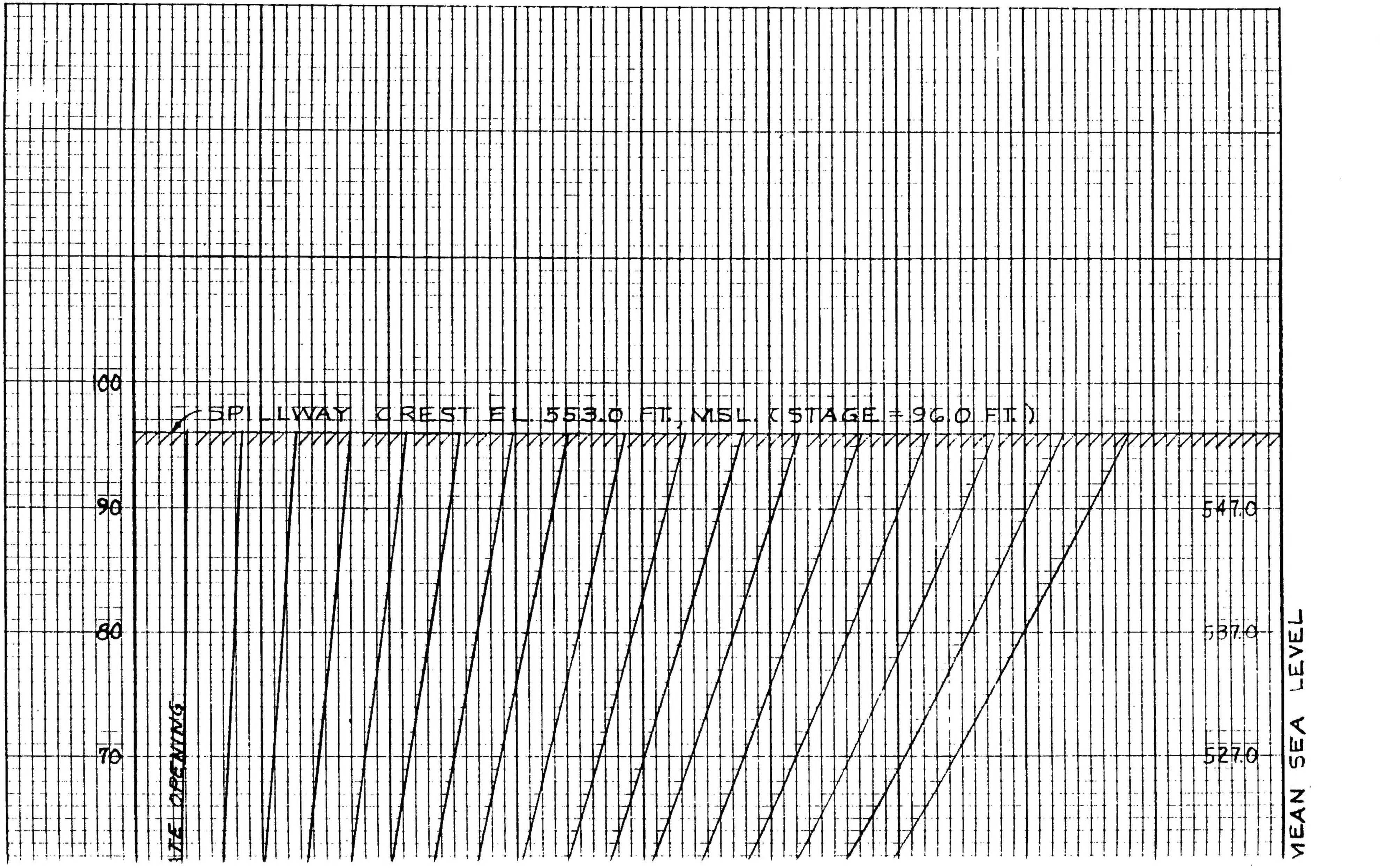
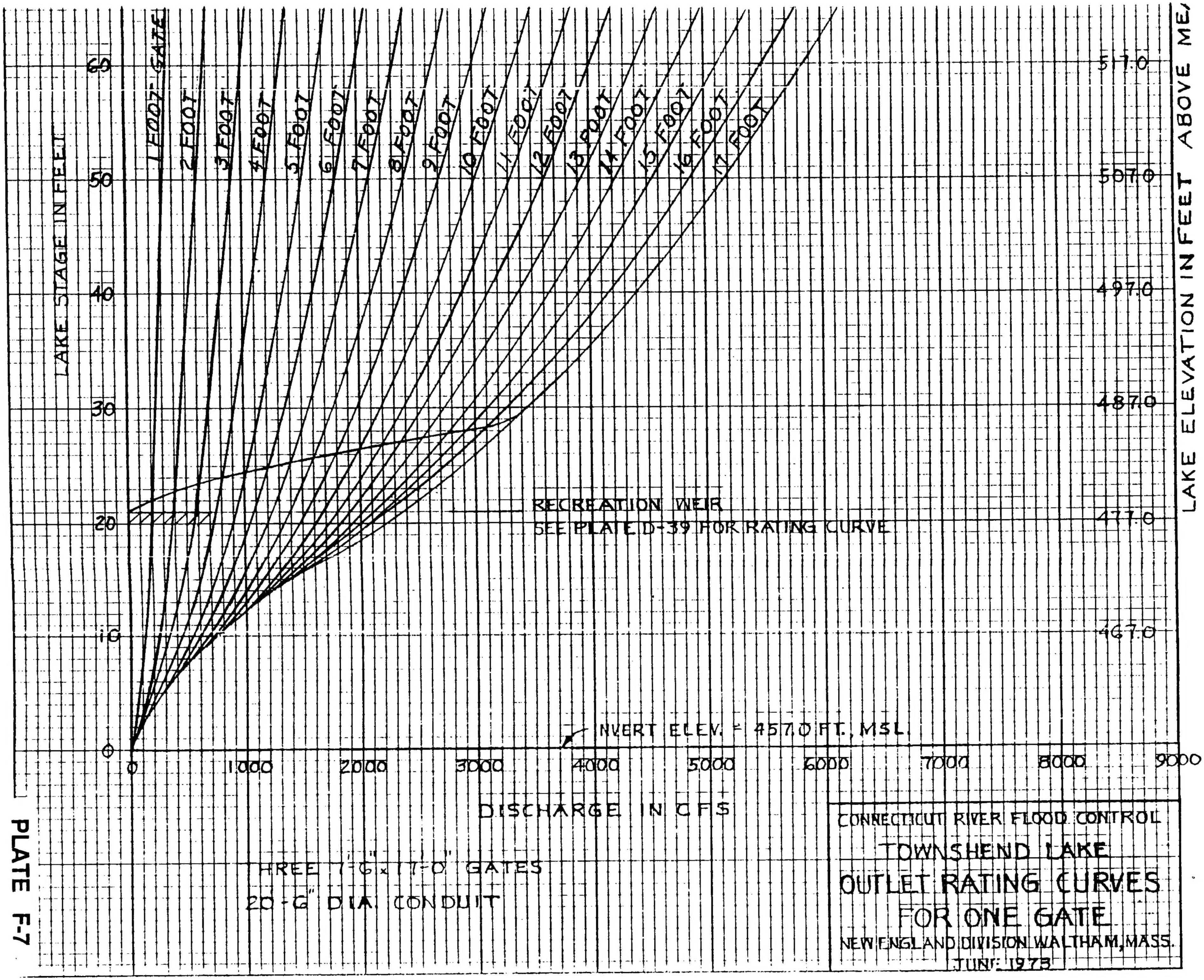

LAKE STAGE IN
LAKE ELEVATION IN FEE
0
20
40
60
80
100
825.5
845.5
865.5
885.5
905.5
1 FOOT GATE
2 FOOT
3 FOOT
4 FOOT
5 FOOT
6 FOOT
7 FOOT
8 FOOT
9 FOOT
10 FOOT
NVERT ELEV = 805.5 FT., M.S.L.
0
500
1000
1500
2000
2500
3000
3500
4000
4500
DISCHARGE IN CFS
THREE 5'-8"x10'-0" GATES
13'-6" DIA. CONDUIT
CONNECTICUT RIVER FLOOD CONTROL
BALL MOUNTAIN LAKE
OUTLET RATING CURVES
FOR ONE GATE
NEW ENGLAND DIVISION WALTHAM, MASS.
JUNE 1973

PLATE F-6

(1)

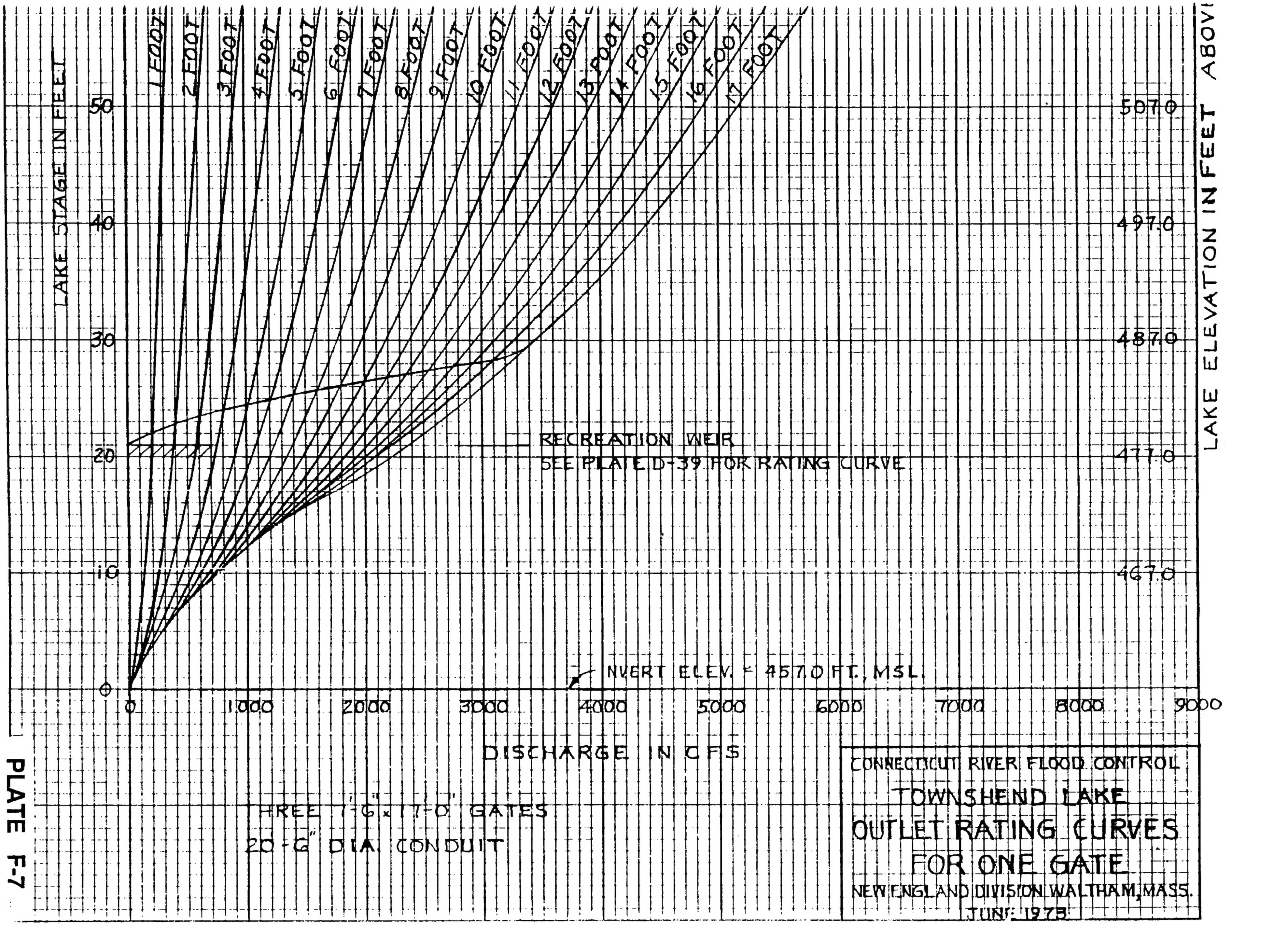


SPILLWAY CREST EL. 553.0 FT., MSL. (STAGE = 96.0 FT.)
100
90
80
70
547.0
537.0
527.0
TE OPENING
MEAN SEA LEVEL



LAKE STAGE IN FEET
LAKE ELEVATION IN FEET ABOVE ME
DISCHARGE IN CFS
0
10
20
30
40
50
60
1000
2000
3000
4000
5000
6000
7000
8000
9000
467.0
477.0
487.0
497.0
507.0
517.0
1 FOOT GATE
2 FOOT
3 FOOT
4 FOOT
5 FOOT
6 FOOT
7 FOOT
8 FOOT
9 FOOT
10 FOOT
11 FOOT
12 FOOT
13 FOOT
14 FOOT
15 FOOT
16 FOOT
17 FOOT
RECREATION WEIR
SEE PLATE D-39 FOR RATING CURVE
NVERT ELEV. = 457.0 FT. MSL.
THREE 7'-6"x17'-0" GATES
20'-6" DIA. CONDUIT
CONNECTICUT RIVER FLOOD CONTROL
TOWNSHEND LAKE
OUTLET RATING CURVES
FOR ONE GATE
NEW ENGLAND DIVISION WALTHAM, MASS.
JUNE 1973

PLATE F-7



LAKE STAGE IN FEET
LAKE ELEVATION IN FEET ABOVE
1 FOOT
2 FOOT
3 FOOT
4 FOOT
5 FOOT
6 FOOT
7 FOOT
8 FOOT
9 FOOT
10 FOOT
11 FOOT
12 FOOT
13 FOOT
14 FOOT
15 FOOT
16 FOOT
17 FOOT
0
10
20
30
40
50
467.0
477.0
487.0
497.0
507.0
RECREATION WEIR
SEE PLATE D-39 FOR RATING CURVE
INVERT ELEV. = 457.0 FT. MSL
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
DISCHARGE IN CFS
THREE 7'-6"x17'-0" GATES
20'-6" DIA. CONDUIT
CONNECTICUT RIVER FLOOD CONTROL
TOWNSHEND LAKE
OUTLET RATING CURVES
FOR ONE GATE
NEW ENGLAND DIVISION, WALTHAM, MASS.
JUNE 1973

PLATE F-7